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GREEN MECHANICAL TIME FUZZES

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TECHNICAL REPORT No. 491-45

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GERMAN MECHANICAL TIME FUZES

SUMMARY

The purpose of this investigation was to discover the trend of development and design of Mechanical Time Fuzes. Essentially only two of seven production plants contributed new ideas on the subject. The trend in development may be characterized as a search for means of setting the fuze in the gun barrel and the latest designs show a demand for dual purpose fuzes as well as a desire to make the fuze independent of the spin of the projectile.

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## GERMAN MECHANICAL TIME FUZES

### 1. The Krupp Type Mechanical Time Fuze.

#### (a) General.

The Krupp type Mechanical Time Fuze was improved during the War years. The design of this Fuze lends itself readily to adaptations, some 30 being known, most of them unimportant for the purpose of this report.

#### (1) Description of Zt.Z.5/30.

Referring to Figure 1, the clock is operated by a main spring adapted to rotate a central hollow shaft which is slotted to accommodate and in turn rotate the Firing Arm Retainer (1). The hollow shaft contains a helical spring, compressed as shown. The F. A. Retainer is held axially against the compressed spring by an Annular Ring (2) which is integral with the adjustable Cap. The F. A. Retainer is held in its zero position by a Sear (3).

In operation, the Cap is rotated, by the Fuze Setter, the desired number of degrees whereby the firing slot is moved to the required position. As the bullet is fired the setback force depresses the Sear (3), the F. A. Retainer is moved counter clockwise held in its plane by the annular ring (2) until it just passes the firing slot projection (4). The F. A. Retainer is now forced forward by the Spring (5) releasing the Firing Arm (6). The Firing Arm, rotated by the spring (7) allows the Firing Pin (8) to rotate. The projection (9) on the Firing Pin slips off the cone shape Gudgeon (10) urged by the Spring (7) and fires the primer which is located directly beneath the Firing Pin in the Body (not shown).

#### (2) Safety Devices.

While the F. A. Retainer (1) is in the zero position it is stopped from rotating by set back sear (3) and retained axially by Bracket (13). It is thus possible to set the Fuze

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1. (a) General (cont'd).

by rotating the Cap with its annular ring throughout 360° without firing while in the Fuze setter.

The Blocker Arm (14) prevents the Firing Pin from firing until the Fuze is rotated at about 50 R.P.S. Above this spin the Blocker Arm rotates, against a spring, to clear the Firing Pin.

(3) Notes on Operation.

The Fuze operates freely and may be handled and assembled to the Round safely. It is waterproofed externally with wax but no dessicant has been used within the Fuze to absorb the remaining moisture.

The two wedges that lock the cap in position at setback operate at about 2000 g, estimated to be just before the rotating band engages the rifling in a gun similar to our 3" and the setback sear releases the timing mechanism at about twice this value. We expect that the cap with its firing slot will stay in the set position, and not twist, due to the high angular acceleration experienced when the rotating band engages the rifling.

(4) Notes on Adjustment.

The fuze is adjusted and tested for timing statically:

The escapement Lever of, for instance, a 30 second Fuze, has a frequency of 132 cycles. The clock is started and the rate of the Escapement Lever is observed stroboscopically. The effective part of the Hairspring is made longer if the rate is too high and shorter if the rate is too low. If the limit of adjustment is reached and the rate is still too high another Escapement Lever is mounted; if the rate should be too low the two brass weights on the Escapement Lever are reduced in weight thereby reducing the rotary moment of Inertia and increasing the natural frequency of the system.

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1. (a) General (cont'd).

It is noted that only one end of the Hairspring is subject to adjustment. The Escapement Lever is mounted so that it can be replaced without tearing down the clock and the escapement wheel is readily adjustable to match.

The clock is tested in a fixture for elapsed time by comparison with a seconds pendulum. An electromagnetic release for the pendulum is synchronized with the starting of the clock. The fixture simulates the annular ring in the cap and when the F. A. Retainer is released through the slot in the jig, an electromagnetic brake stops the pendulum. The elapsed time is held from .05 to .1 seconds for 30 and 60 second Fuzes in the factory.

This system of adjusting and testing is somewhat slower than the Electronic Rate Testing System used in American factories. There is no objection to testing the clock statically (i.e., not spinning), the error due to centrifugal Force on the Hairspring is substantially a constant, although a different constant for each range of spin.

(5) Notes on Design and Production.

Evaluating the basic design of the Fuze we note that the clock is short axially because the Primer requires no great Firing-Pin velocity. This allows the designer to place the clock well to the rear in the Body and the assembly becomes more rugged. The four plates are securely held together with three throughscrews which are also used to bolt the clock to the body making a substantial assembly. The running friction has been reduced by using only 3 gears and by making the escapement wheel very light.

The main spring is highly stressed, a common practice in the design of clocks and caused many rejections due to breakage. It is estimated that 18% of Krupp type Fuzes in Africa were inoperative due to broken main springs.

The escapement is self-starting and there is little difference in torque required to start and to run. The method of cocking the firing pin is no better than that used in other mechanical Time Fuzes. The idea of separating the two elements

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1. (a) General (cont'd).

which initiate the firing, i.e., the F. A. Retainer and the Slot in the annular ring, instead of mounting them in the same unit is very poor practice. The setback release scheme is fair. There is no need to take up backlash in the geartrain. The design lends itself to variations for special purposes as we shall see below. The workmanship is excellent.

The Krupp type mechanical time fuze was improved over the basic design by Gebruder Thiel, clock and watch manufacturers in Thuringia. Four plants produced approximately 15,000 daily up to 1942. Subsequently only two plants were producing this fuze at the rate of about 7,000 daily. The fuze described cost the Government 10 marks each.

(b) Delayed Arming Time Fuzes.

(1) Description .

Reference is made to Figure 1A. Item 2 is the annular ring in which the firing slot is located. A similar annulus (3) with an arming slot is fastened to the top plate of the clock. The arming slot is of course quite similar to the firing slot, although the functions of the two slots are different.

Assuming that the clock is started by the setback force, the Firing Arm Retainer is now kept in its plane of rotation by the fixed annulus until it reaches the arming slot when it is forced forward against the adjustable annulus. Continuing to rotate in this new plane, the Firing Arm Retainer finally reaches the firing slot and the Fuze fires.

(2) Comments.

The scheme was used in Fuzes for 380 mm and 406 mm guns. In such large caliber guns, the low setback force requires that the Release Sear is set to operate at about 60% of the value for smaller caliber guns. The delayed arming is an additional safeguard against prematures and well adapted for longer time settings. For instance, if we decided that we would not want to

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1. (b) Delayed Arming Time Fuzes (cont'd).

set the Fuze for less than 10 seconds time and that a time as long as say 40 seconds was desired. By using the above described construction our opportunity for accurate time setting would be 1/4 or 25% better than if we were to use the conventional method.

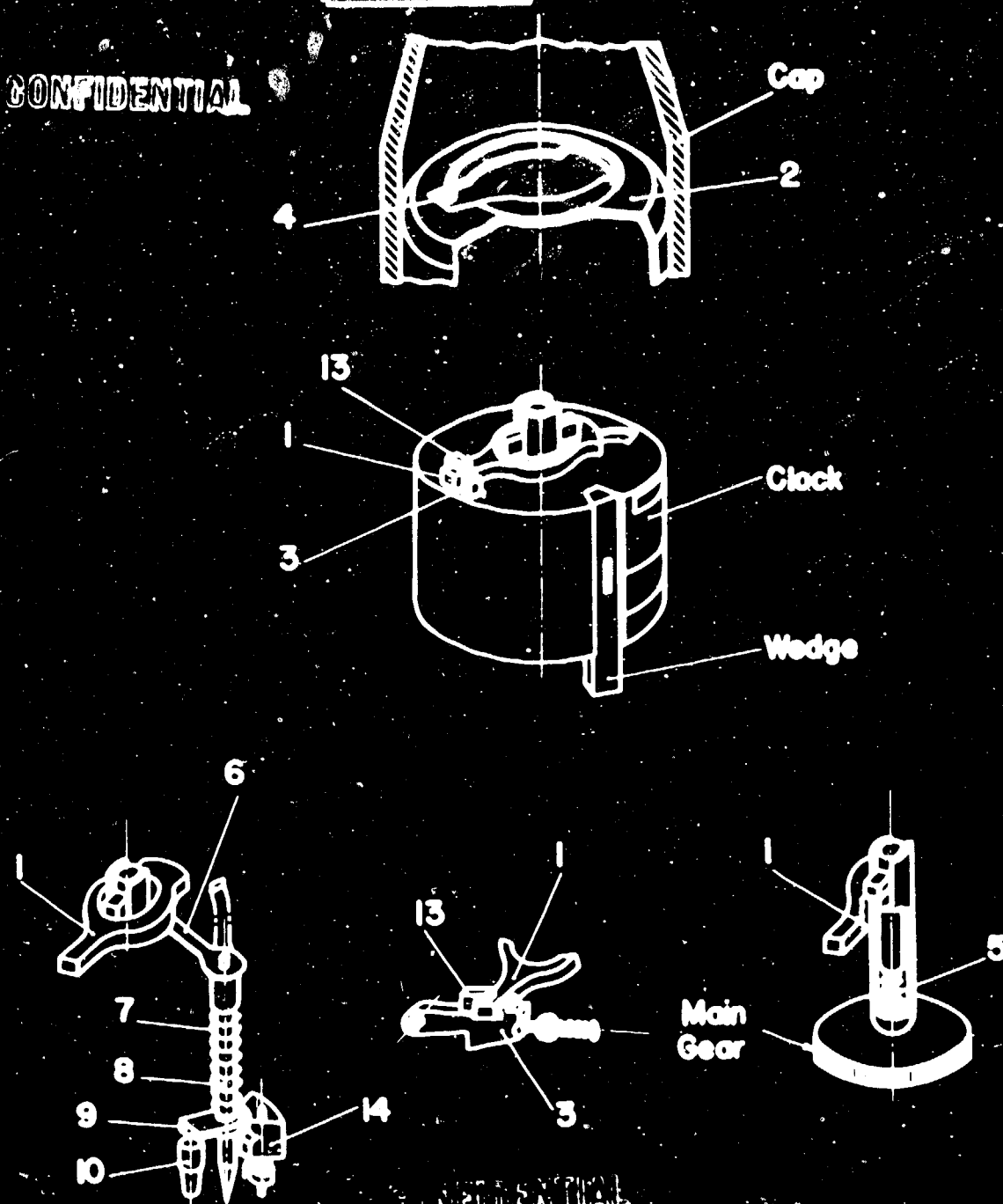
(c) Ballistic Tests.

A few reports of ballistic tests have become available. Figure 1B shows test results on 5 sec., 30 sec. and 45 sec. Krupp type Mechanical Time Fuzes.

In connection with the test on the 45 sec. Fuze on December 12, 1943, the statement was made (by O.K.L.) that the 45 sec. Fuze was entirely useless. It was thought that the errors were due to Cap slippage and extensive tests were made using Fuzes in which the adjustable caps were fastened to the Bodies, by means of screws against other Fuzes with Caps having standard torque. No great difference was found. Six months later, the situation with respect to 45 sec. Fuzes had improved.

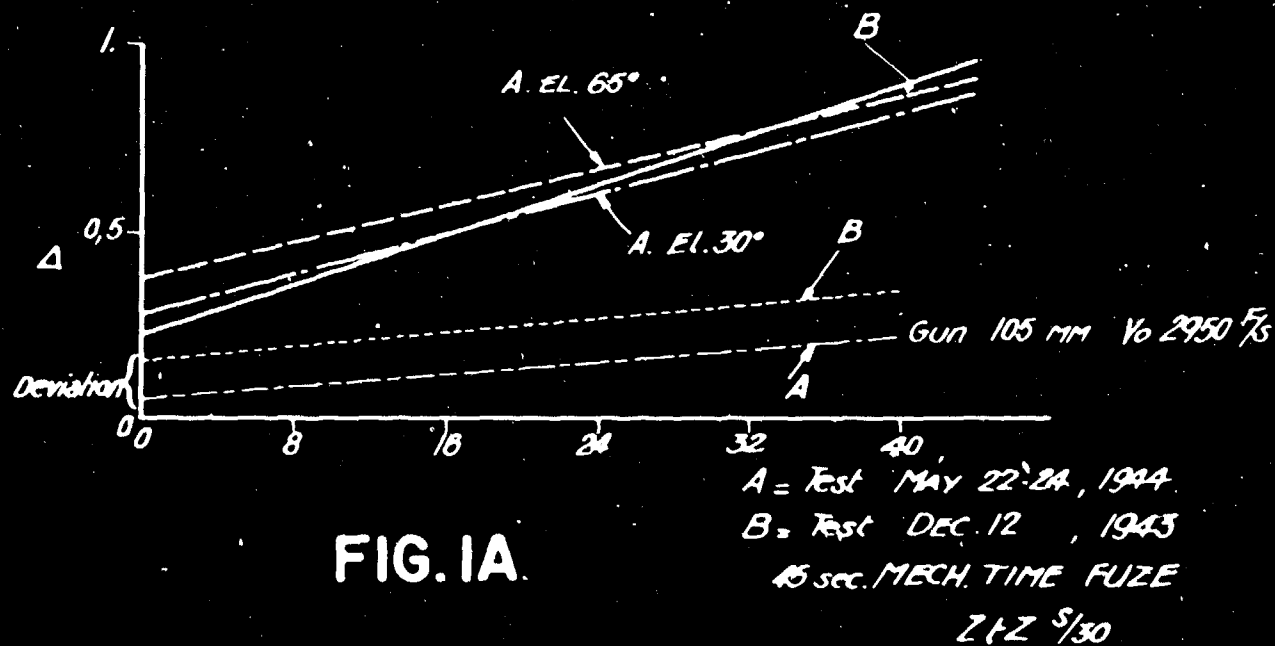
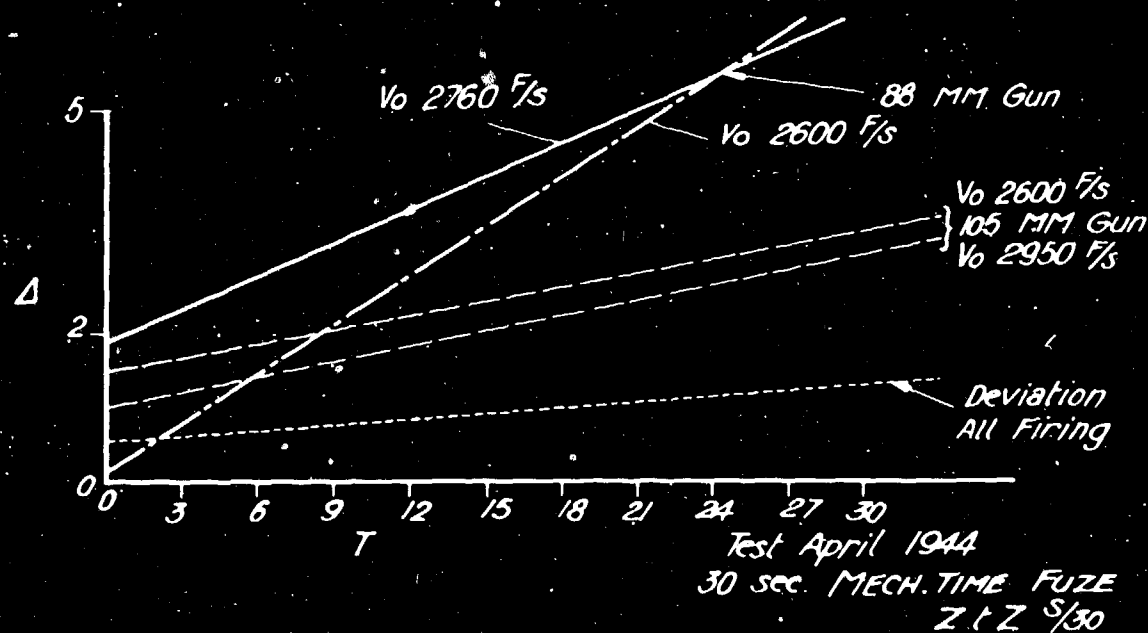
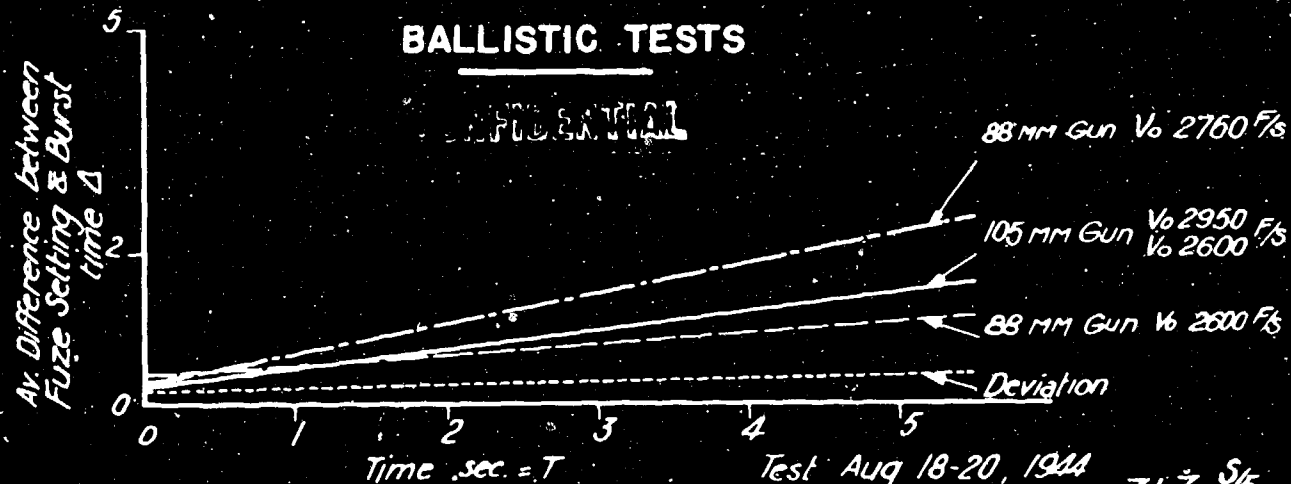
# KRUPP TYPE MECHANICAL TIME FUZE

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FIG. 1



**FIG. 1A.**

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2. The Junghans Type Mechanical Time Fuze.

(a) General.

Distinct from the Krupp type fuze, which as we have seen is operated by a mainspring, the motive power for the Junghans type fuze clock is derived from centrifugal force. The Junghans fuze was used in large quantities during the entire war. It is described here because the centrifugal drive and the firing mechanism were completely redesigned just prior to the war.

(b) Description of Fuze Zt.Z S/30 Fg.

Figure 2 shows the firing mechanism in the armed and fired position. The timing disc (1) rotates clockwise with its firing slot into which the firing arm (2) is moved thereby turning its shaft axially. The plate (3) which was held from operating by the firing arm shaft can now rotate outwards through the slot as indicated in the figure. The plate (3) is fastened to an auxiliary shaft (4) which therefore rotates with the plate. The lower flattened portion of the auxiliary shaft kept the hook shaped sear (5) from disengaging the primer container (6) until the auxiliary shaft turned about its axis. The sear now rotates outward, the primer container thereby released moves toward the firing pin (7). The motions of all members described are derived from centrifugal force and are shown in the final fired position in Figure 2B.

Earlier in the war a flat spring was placed between the primer container and the plate where the helical spring (8) is now shown. The purpose was to augment the motion of the primer container to insure firing but this construction was found to be dangerous and the spring was replaced by the weak helical spring shown to prevent the primer container from rattling.

Figure 2A shows the centrifugal drive and a bottom view of the clock. In the bottom view (1) is a safety plate urged into safe position by spring (2). Immediately above the safety plate is located a set back pin (not shown) with a hemispherical point bearing on the hole in the safety plate, making the arrangement here safe. The escapement is released, to start the fuze clock, by the set back pin (4) which is held in position by spring (5).

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2. (b) Description of Fuse Zi.Z S/30 Fg (cont'd).

In the top view of Figure 2A is shown the centrifugally operated drive. The weighted gear sectors (1) operate the central pinion (3) through the two pinions and gears (3). Beneath each gear sector is located a weak hairpin shaped spring to urge the sectors towards the periphery of the clock. These springs are too weak to contribute any appreciable force to the drive but merely keep the gear teeth in contact to avoid backlash in the gear train. The gear sectors (1) are slotted as shown at (4) to take up, yieldably, the shock of the angular acceleration experienced when the rotating band of the bullet enters the rifling of the barrel. In a worn gun the value of this acceleration is of considerable magnitude due to the run up of the projectile.

Although not shown two stops were provided to prevent the hairspring from breaking or taking a set at the moment of maximum angular acceleration. The stops are of course arranged so that the hairspring may operate freely at all other times.

Figure 2B shows a plot of the available torque on the central pinion.

(c) Notes.

The fuse clock is regulated by observation of elapsed time. The regulating machine has a mounting fixture for clock containing two electric contact members which are arranged so that one starts and the other stops a master clock. The fuse is placed in the mount and rotated at 16,000 R.P.M., contact member #1 holding the escapement lever to prevent the fuse clock from starting until it reaches the desired velocity, whereupon actuated by the centrifugal force, the contact operates to start the fuse clock and the master clock simultaneously. The timing disc has previously been set at 30 seconds and when the fuse clock fires the auxiliary shaft (4) Figure 2 operates contact member #2 to stop the master clock. The elapsed time is read and adjustments of hairspring length are made, if necessary, to secure satisfactory operation.

The Junctions type fuse was made in considerably larger quantities than the Krupp type. It is estimated that about 250,000 units were made monthly from 1937 to 1942. From 1942 to 1944 the Kodak

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2. (c) Notes (cont'd).

factory changed from Krupp to Junghans fuzes adding another 100,000 units per month to the total capacity for the manufacture of this fuze.

The price to the Government was 11 marks for the ZT. Z. Fg and 14 marks for Dopp Z S/60 Fg.

JUNGHANS TYPE MECHANICAL TIME FUZE  
DIAGRAM SHOWING FIRING MECHANISM

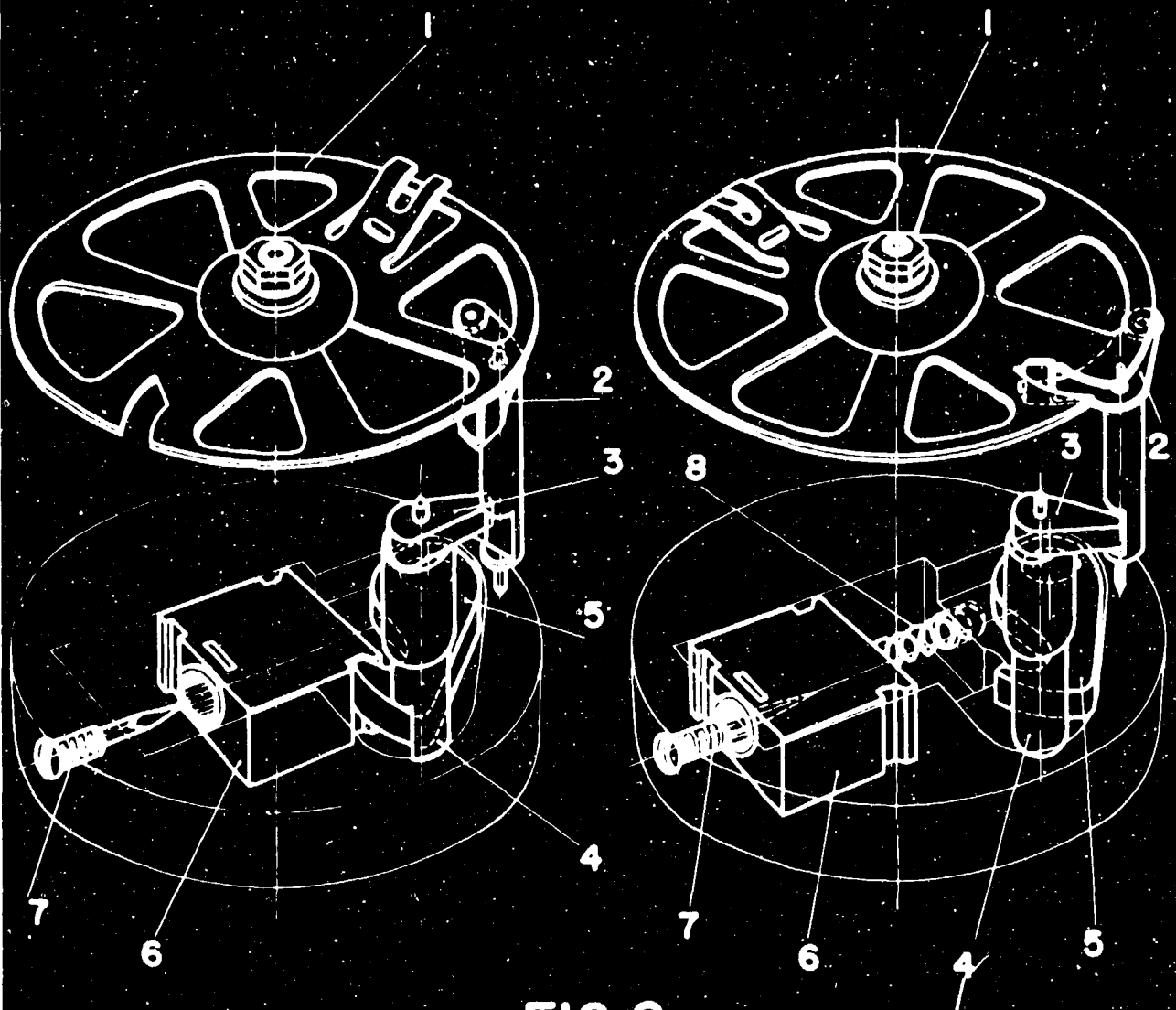
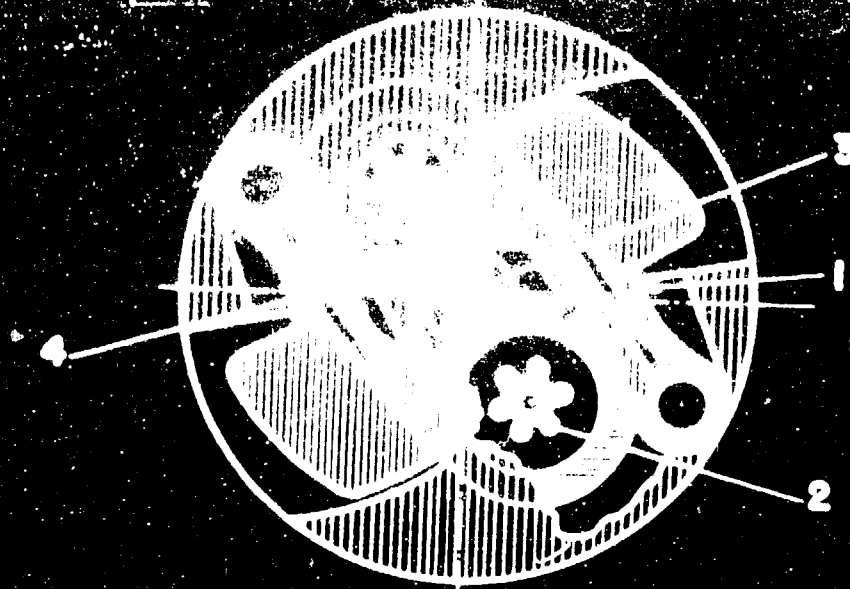


FIG.2

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**a. Centrifugal Drive**



# JUNGHANS MECHANICAL TIME FUZE

## TORQUE AT CENTER PINION

Weight of segment = 6,7 gr.

Efficiency 90 %

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2000

1500

cm/gr

1000

500

0

0

5

10

15

20

25

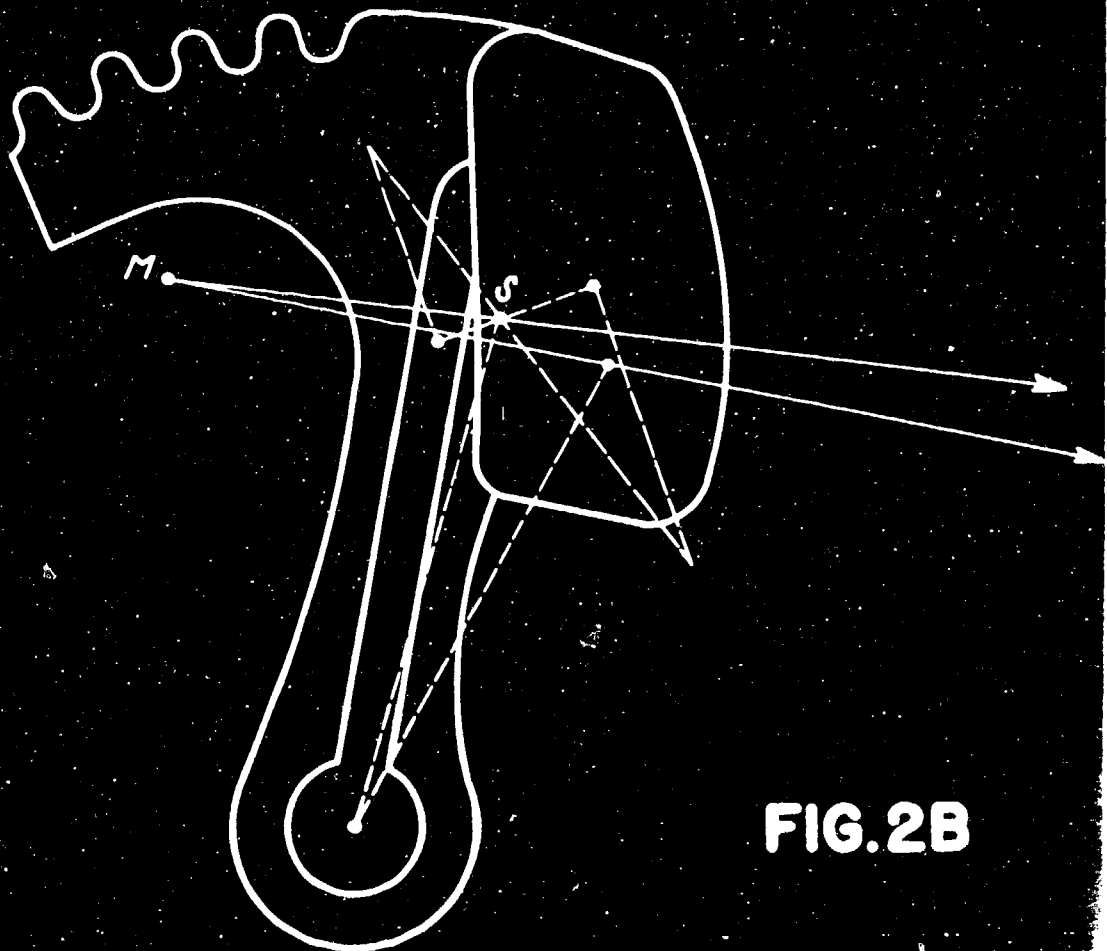
Time in Seconds

$n = 16.000 \text{ RPM}$

M

S

FIG.2B



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3. Combined Mechanical Time and Impact Fuses.

Apparently the need for an impact detonating element in the mechanical time fuze became acute in the summer of 1944. Three distinct kinds were designed between that time and March 1945. In chronological order we have:

- (1) The Krupp Type Base Impact Unit with several minor variations.
- (2) The Junghans Type Point Detonating Unit with three variations.
- (3) The Skoda Type Point Detonating Unit with four variations.

(a) Base Impact Unit.

This unit dates from July 1944 and is shown in Figure 4. Its use was confined to Krupp Type Time Fuzes. Referring to Figure 4 a Plate (1) screwthreaded into the body beneath the Fuze Clock, carries a fixed firing pin (2). Recessed in the body is a cylindrical primer housing (3) retained, in the static position of the fuze, by conventional clapper style detents (4). An anti-creep spring (5) bears against the primer housing.

The mode of operation of this unit is obvious. Some variations are provided with longer bodies admitting larger primers. The combination was known as Dopp. Z s/30, Dopp Z s/60 depending on the maximum running time of the time fuze.

(b) "Jungfrau" Point Detonating Element.

Gebrüder Junghaus developed three quite similar point detonating devices for their mechanical time fuze.

(1) The first design, known as Dopp. Z S/60 Fl, had a gear arrangement for arming the impact unit some distance beyond the muzzle of the gun (Maskensicherheit). Some thousands were made for O.K.M. at "Messap", Hamburg. It was less sensitive than desired.

(2) The second design, known as E. Dopp Z S/30 operated like "Jungfrau" but had two hook shaped centrifugal detents

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3. (b) "Jungfrau" Point Detonating Element (cont'd).

for the impact firing pin. Premature safety of the impact unit (Maskensicherheit) could be varied by a stop for the impact primer which was operated by the number 4 gear in the Fuze Clock. Approximately 60,000 units were made before the war ended.

(3) In response to a demand from the O.K.M. for greater sensitivity of the impact unit the "Jungfrau" was developed and submitted to O.K.M. 8 February 1945. Very few were made and none were used in actual warfare.

Description.

The impact firing pin (1) and the centrifugal detent (4) Figure 5 are assembled to a mounting cup which is threaded into and adapted to be rotated with the Cap. This mount contains also the hammer spring and the set pin. The firing pin (1) is provided with a collar (2) so that it can be held in a safe position by the centrifugally operated detent (4). A light helical spring (3) between the center shaft of the fuze clock and the firing pin sleeve holds the firing pin in position while the bullet is in flight. The detent (4) operates against the spring (5). In the number 6 plate of the fuze clock, is recessed a primer slide (6) which is held out of line with the firing pin by the spring (7) while the clock is stationary. It will be observed that due to the revised Junghaus drive, making the central pinion shorter and larger in diameter a fair sized hole can be drilled axially through the pinion to accommodate the firing pin.

Operation.

The operation of the impact element is shown in Figure 5, the primer fires through the fuze clock into the booster.

(c) Skoda Type Point Detonating Unit.

(1) General.

During February 1945 a point detonating element as a unitary structure was devised and tested at the Skoda Works.

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3. (c) Skoda Type Point Detonating Unit (cont'd).

It had two advantages over the previously described units. First it was more sensitive, second it could be very simply adapted to existing Zt. Z. s/30 time fuzes of which more than seven million were available. The O.K.M. authorized the conversion of existing mechanical time fuzes to Skoda CC Z s/30 on 14 March 1945 as a temporary measure, the ultimate in sensitivity not having been found as yet.

(2) Description.

Referring to Figure 6 it is observed that the CC element (1) is mounted in the cap of the time fuze as a unitary structure. A relatively large charge (2) is adapted to be ignited by the sensitive primer (3). The sensitive primer is urged toward the axis by the spring (4) but is held in safe position by the firing pin (5). The firing pin is held in position by the spring (6) and the ball (7).

(3) Operation.

The unit starts to arm when the round is fired, the set back force acting on the firing pin compresses the spring (6) allowing the ball (7) to fall out into the wide part of the housing (8). After the bullet is beyond the acceleration field of the gun, the firing pin is urged forward by the spring against the dashpot effect of piston (9), the complete arming being thereby retarded for a distance, said to be from 15 to 150 feet beyond the muzzle. The sensitive primer is now free to move into firing position. Upon impact the charge fires through the fuze clock into the booster.

(d) Johann-Super-Zundwerk.

Description.

Figure 7 shows a design which somewhat resembles the Skoda unit in that it could readily be applied to existing time fuzes. The firing pin (1) is retained in the unarmed position by a detent system consisting of a notched plate (2) and an aluminum spiral (3). Between the firing pin and the primer is recessed a centrifugally operated safety slide (4). The operation of the fuze is clearly discernable by inspection of the Figure. Another very

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3. (d) Johann-Super-Zundwerk (cont'd).

similar version of the fuze is shown in Figure 8 and a third device, not shown, and no model, was also made owing to the urgency of the project.

(e) Notes.

No. 2 fuze, Figure 8, was ready first and 40 samples were made and tested. The ballistic tests were satisfactory but the design was rejected, not being moisture proof. No. 1, Figure 7, of which 200 samples were tested was approved by the O.K.M.

Tests were made for sensitivity at reduced velocity and both the Skoda and the Super Zundwerk fired at Vo 450-600 feet per second against 1 mm Duhal or 4 mm cardboard. The premature safety (maskensicherheit) was about 30 feet beyond the muzzle, more definite with the Aluminum Spiral System than with the dash pot system (as in Skoda).

These fuzes were tested about March, 1945 and none were actually used in warfare.

It is worth noting the statements of a PW, relative to the efficacy of the Combination Fuze. In a report issued by the Office of the Director of Intelligence, Hq., USSTAF (Rear), 5 June 1945, Walter von Arthelm, General der Flakartillerie, former inspector general of flak, was interrogated relative to Fuzes among other subjects. "In the latter period of the war, planes were so well constructed and armored that HE projectiles had to burst within 4 meters of a plane to be effective."

"It was calculated (on probable errors) and confirmed experimentally that a 4-motored plane such as B-17 or B-24 would receive a direct hit once in about each one thousand rounds fired."

"This fuze was developed to burst on impact and if contact was not made on a plane, then on time as with the customary time fuze. It was very successful and per plane, dropped from 3000 rounds with time fuzes to 900 round with this Fuze."

"This fuze went into production in the fall of 1944. In October, 1944, production was 1800-2000 fuzes and this was to be

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3. (e) Notes (cont'd).

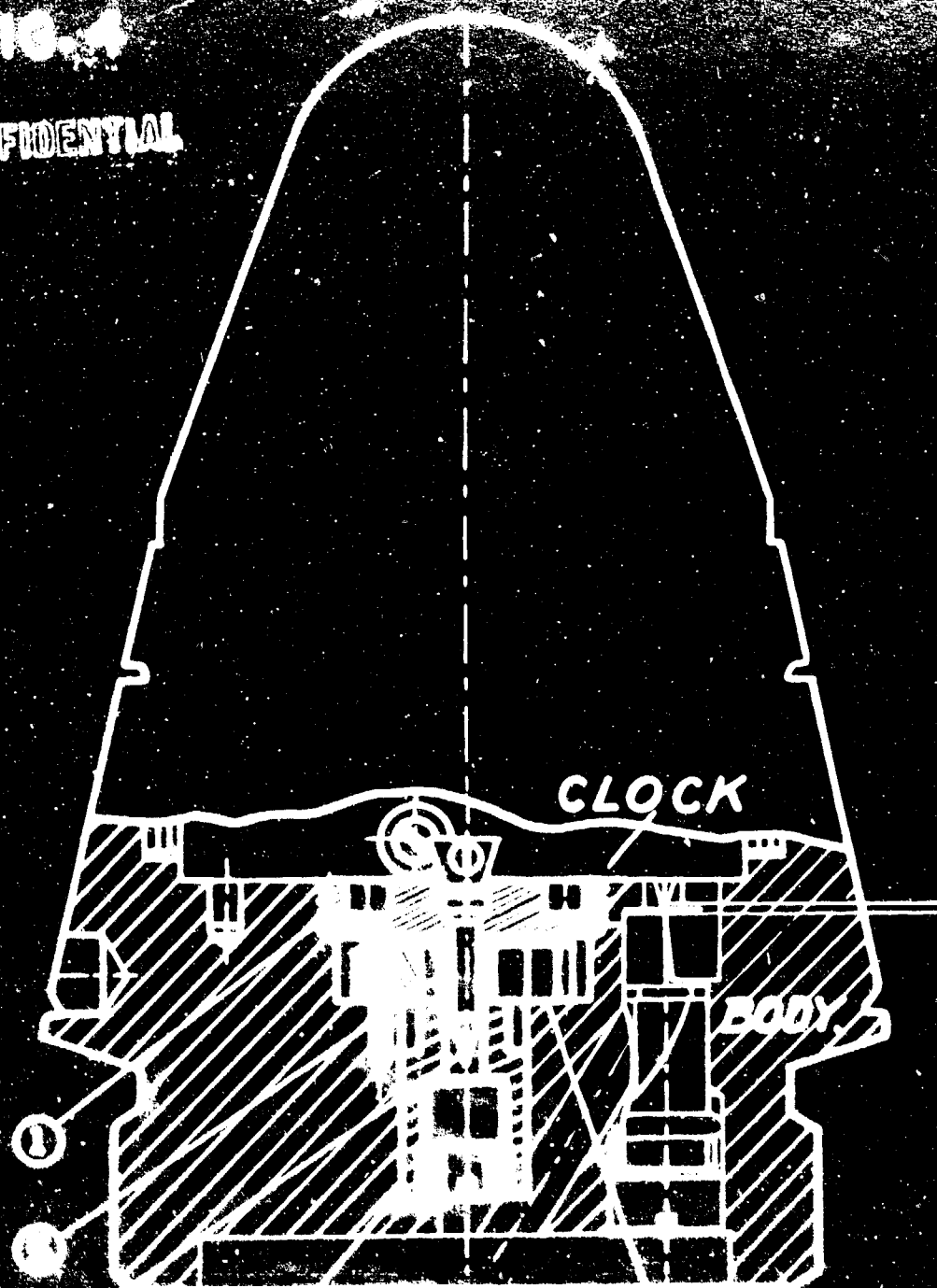
increased rapidly until production of fuzes would be of this type."  
(Quoted verbatim.)

The fuze referred to is E Dopp Z S/30, the immediate precursor of "Jungfrau" (See "Jungfrau" second design above).

We can readily see how both of these figures for numbers of rounds would have been a great deal smaller had the Germans succeeded in developing a good mechanical time fuze, to be set for "time to burst" while in the gun barrel, thereby eliminating the dead time as will be discussed in Part 4.

FIG. 4

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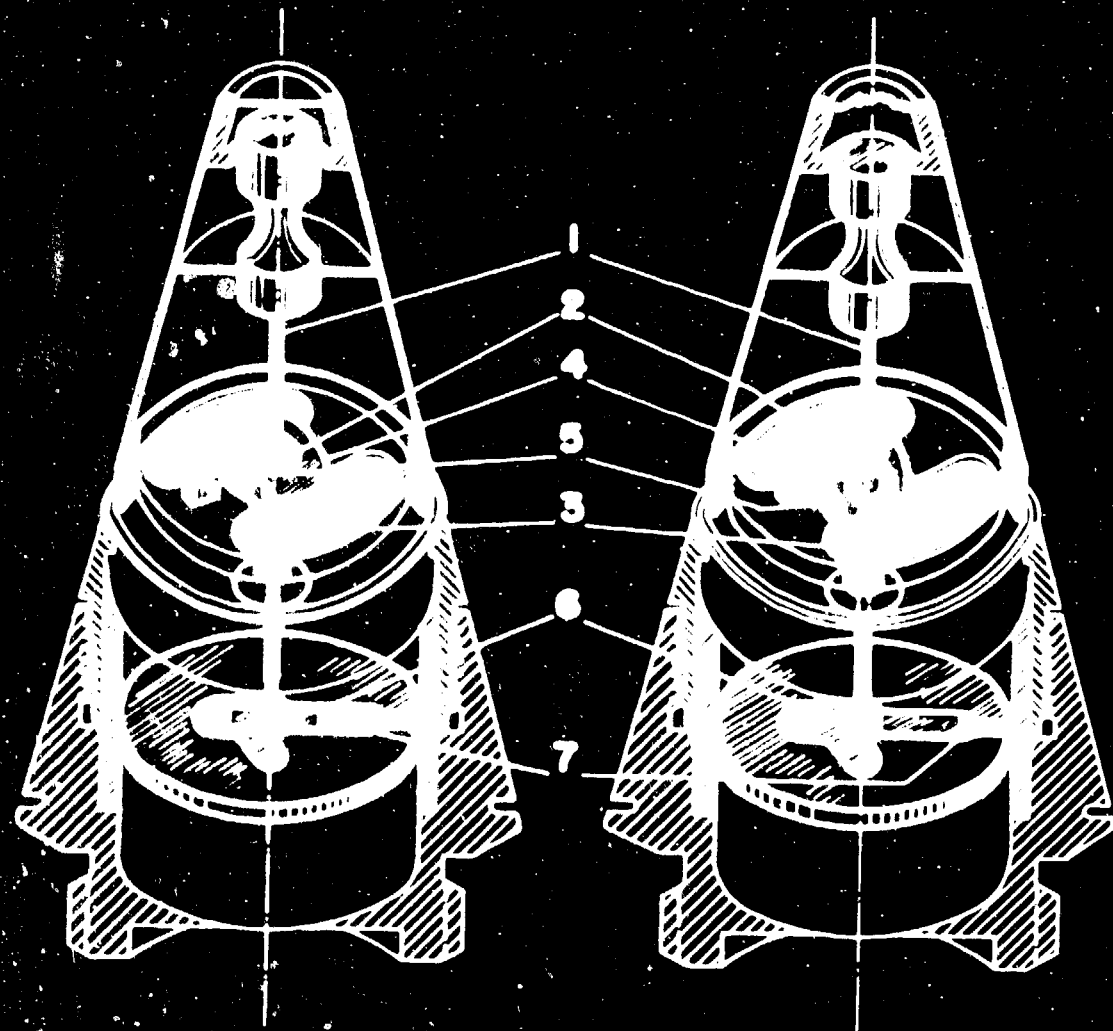


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FIG. 5

Safe Position

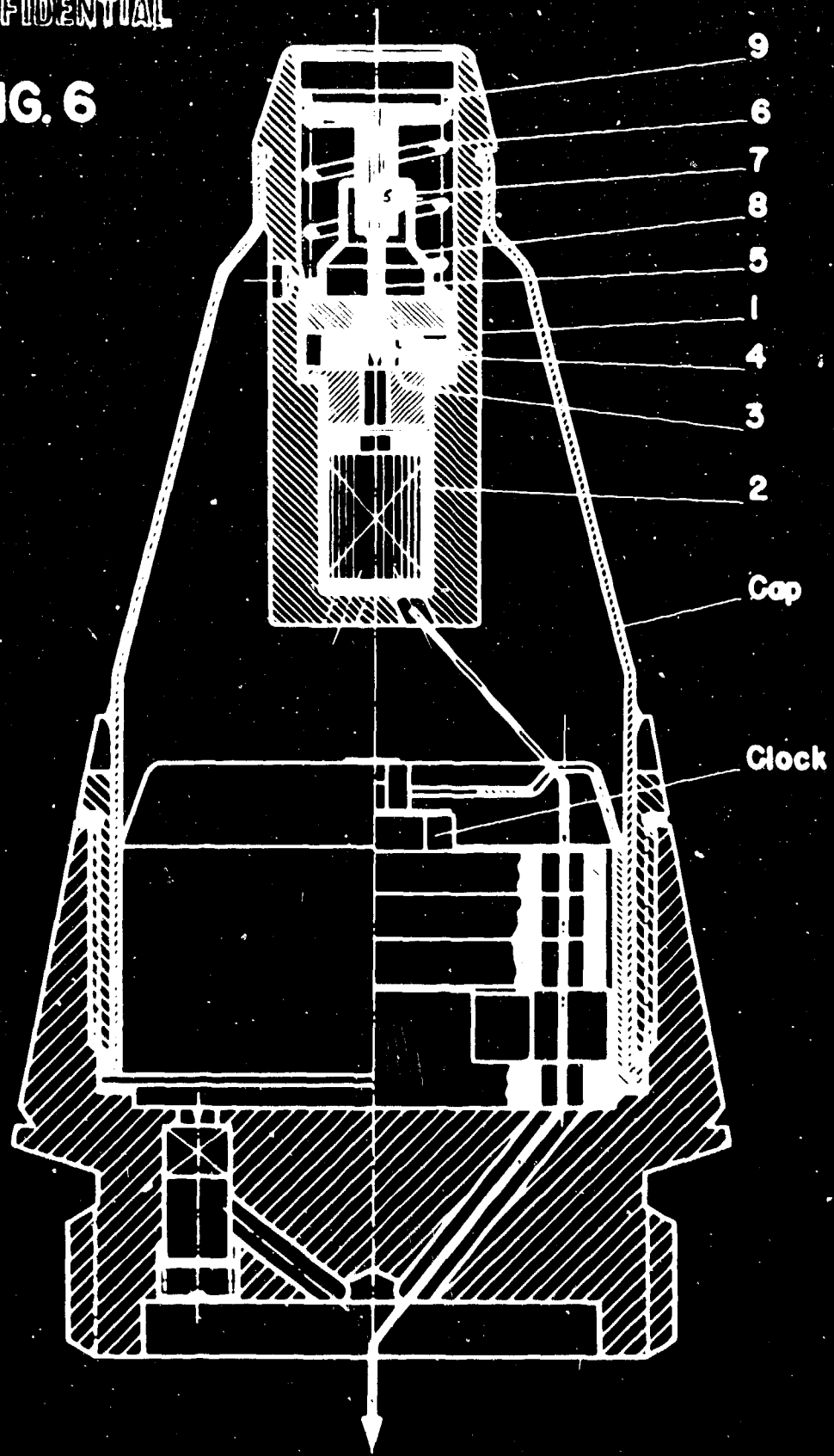
Firing Position



COMBINED MECHANICAL TIME & IMPACT FUZE  
SKODA PERCUSSION ELEMENT (Z1. Z S<sub>30</sub>-CC)

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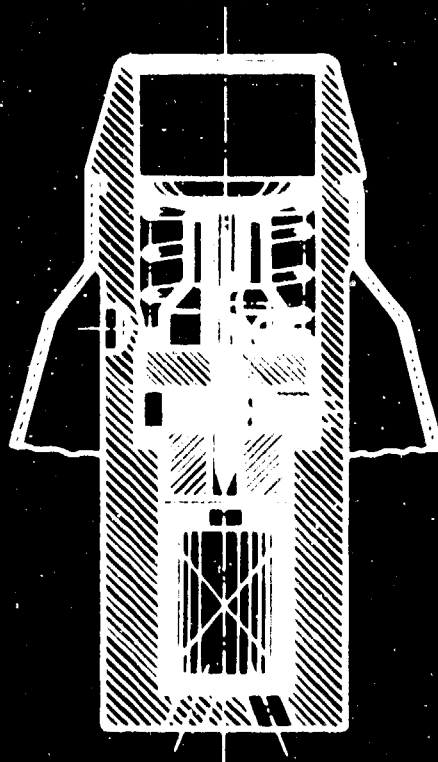
FIG. 6



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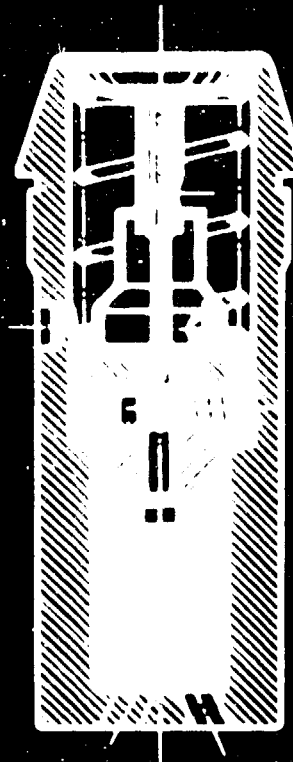
**FIG. 6a**

**Process of Arming  
during Set Back**



**FIG. 6b**

**Fully Armed**



COMBINED MECHANICAL TIME & IMPACT FUZE  
No 1- JOHANN & SUPER ZUND WERK

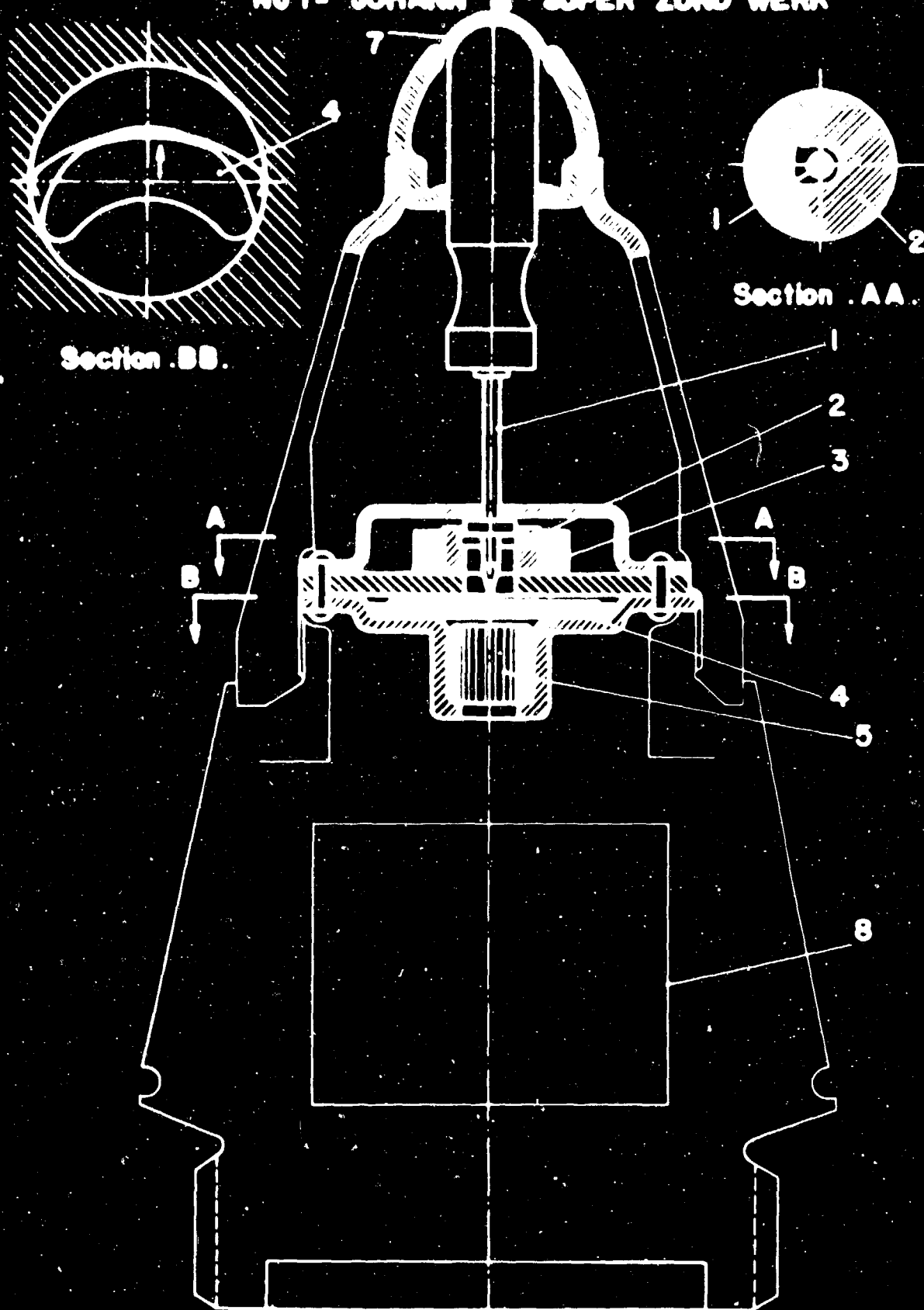


FIG. 7 CONFIDENTIAL

COMBINED MECHANICAL TIME & IMPACT FUZE  
No. 2 JOHANN SUPER  
ZÜND WERK

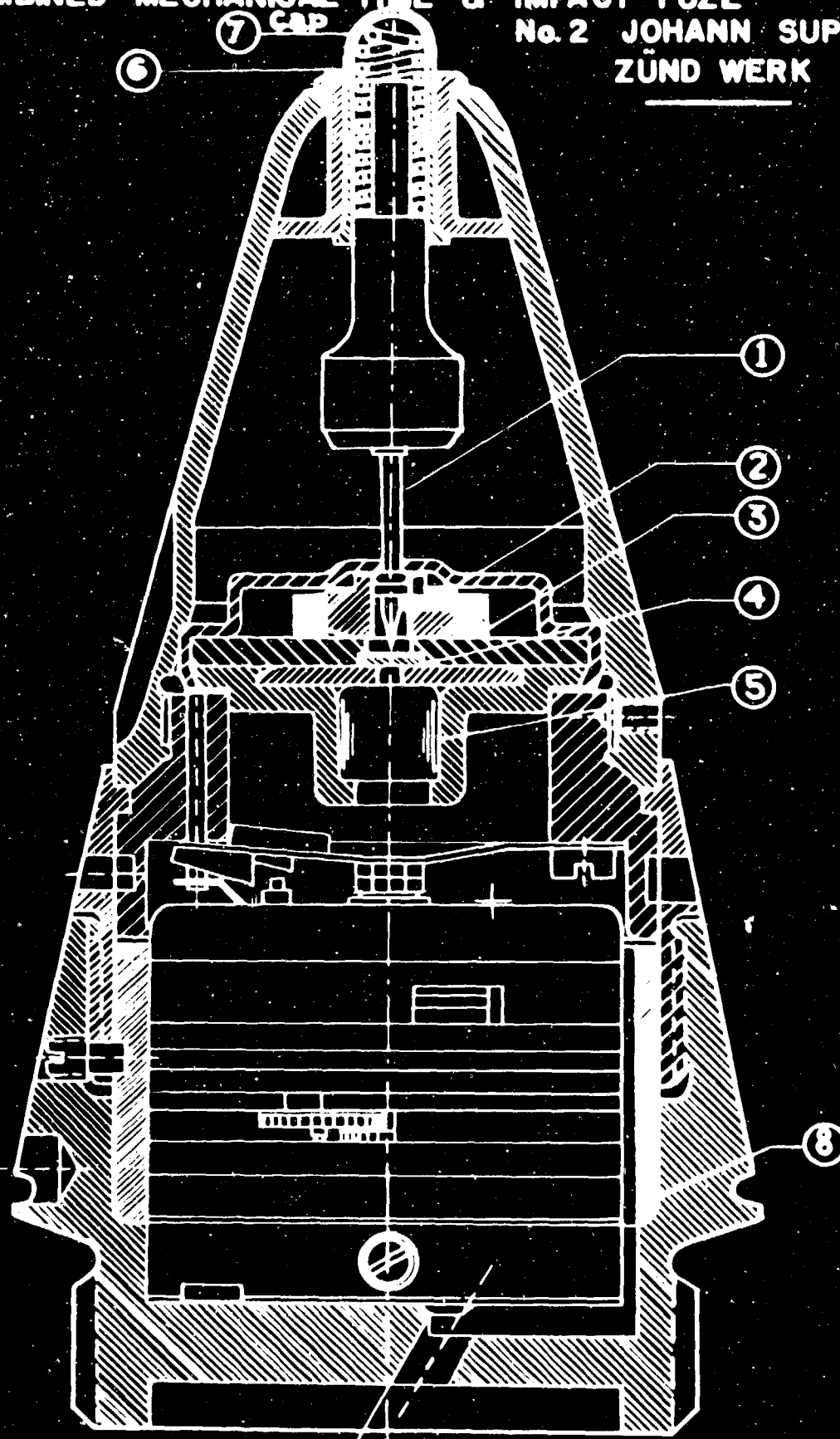


FIG. 7a CONFIDENTIAL

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4. Mechanical Time Fuze Devices for Eliminating Dead Time.

The mechanical time fuze has an inherent possibility of accuracy far beyond that of any other fuze known to date. Unfortunately present usage permits a variable error between the process of setting the fuze for "time to burst" and the actual firing of the gun. This variation, amounting to many times (10) any timing error existing in the fuze itself, obviously makes the fuze much less useful than intended.

Both the British and Germans have tried to develop devices to eliminate all or part of this dead time, and while none of these devices has been used in actual warfare, nevertheless the subject seems sufficiently important to warrant a brief summary of what has been done to date.

(a) The Midgeley Time Fuze.

(1) General.

The Midgeley time fuze was devised and constructed by the Midgeley-Harms Co., Ltd., London about the beginning of the war. It has been offered to the British Government and it is said that while the British Navy would like to have it made in some quantity, the Government was not in a position to assign the necessary workmen to the company.

The fuze was designed to be set for "time to burst" after the round has been rammed, by acoustic means. No actual firing tests have been made but the fuze and associated gear has been found to operate satisfactorily in dummy trials.

(2) Description of the Fuze.

The standard British mechanical time fuze is of the Krupp type described in Part 1, in which the firing arm container, after release of the set back arm rotates counter clockwise restrained in the plane of rotation by an annulus. When the firing arm container reaches the firing slot in the annulus it moves axially releasing the firing arm which in turn releases the firing pin.

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4. (a) The Midgeley Time Fuze (cont'd).

In the Midgeley Fuze shown diagrammatically in Figure 8 we have a standard fuze clock (1) and also an auxiliary clock (2) which rotates the annulus (3). It will be recalled that in the conventional Krupp type time fuze the firing slot is located in an annulus which is part of the cap and that the "time to burst" is set by rotating the cap with respect to the body thereby placing the firing slot in the annulus in the desired geometrical position. In the Midgeley fuze the annulus with its firing slot, is constantly rotated by the auxiliary clock. The appropriate geometrical position of the firing slot becomes fixed only at firing of the round when the set back force will cause the annulus to be impinged upon a number of fixed sharp pins.

Into the body is secured a reed (6) and on the rim of the annulus is affixed a pluck (5) in such a way that for each revolution of the annulus the pluck strikes the reed to emit a sound. As embodied in the latest model the annulus makes one revolution per second and the reed emits a 3000 cycle note each second. Because the position of the pluck with respect to the firing slot in the annulus is fixed, the 3000 cycle note definitely locates the firing slot distance from the zero point of the firing arm container.

In operation the round is picked up, pin (7) manually depressed to start the auxiliary clock and the round is rammed. The rim of the cartridge case, (see Figure 8B) makes physical contact with the projecting part of a microphone (11) which is fastened to the breech end of the gun. Every sound emitted is now picked up by the microphone, amplified and filtered to exclude all but the fundamental of 3000 cycles.

On to the dial of the predictor (16) is affixed one contact and another contact is fastened to a rotating arm (13), both being in the firing circuits. Rotating arm (13) is adapted to be rotated through a friction drive by means of a synchronous motor, turning one revolution per second, precisely like the annulus in the fuze. A relay (12) serves to hold the arm at the zero position against the friction drive as illustrated in Figure 8.

The round is in the gun and at the first 3000 cycle

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4. (a) The Midgeley Time Fuze (cont'd).

signal picked up by the microphone the relay is actuated, releasing the rotating arm. The contact on the predictor dial can be adjusted by the fire control gear up to the time that it is desired to close the firing circuit elsewhere, whereby the contact on the dial becomes alive and when next it is actuated by the rotating arm fires the gun. The rotating annulus having been synchronized by the 3000 cycle note operating the relay, the fuze is evidently set for "time to burst" at the instant of contact. To achieve a high order of accuracy the auxiliary clock has an escapement frequency of 700 cycles and is well designed. The running time of this clock is 30 seconds, thus the round must be fired within this time after the clock has been started.

(3) Notes.

This method of eliminating dead time has a number of drawbacks which are immediately apparent, as well as introducing in itself an error larger than the one it intends to eliminate.

It may be mentioned here that attempts were made to pick up the sound without metallic connection but it turned out that even a slight coating of grease tends to attenuate the 3000 cycle note so that it is completely masked by random noises. The necessity for metallic connection severely limits the utility of method.

It will be observed that the present arrangement takes no account of the time elapsing between contact in the firing circuit and the actual set back which locks the annulus in place. If this time lapse is, say .1 seconds, the annulus obviously makes .1 revolution or  $36^\circ$  which corresponds to an error of more than 3 seconds in this fuze.

(b) Mechanical 2-clock Fuze.

(1) General.

The idea of setting the mechanical time fuze for "time to burst" with the round in the gun barrel was proposed by the O.K.L. about the end of May 1943. Both O.K.L. and O.K.M. were anxious to have this work progress rapidly and two laboratories

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4. (b) Mechanical 2-clock Fuze (cont'd).

were charged with developing, independently, the desired device.

The finished units turned out to be very much alike in principle and only one needs to be described.

(2) Description.

Referring to Figure 9, a Junghans Fuze clock is shown as (1) and directly above a time set clock (2) adapted to rotate the timing disc (3) of the fuze clock at 120° per second for 30 seconds. Figure 8E shows the method of operation diagrammatically. Just before ramming the round was placed into a cup (4) and the time set clock started by manually depressing plunger (5). The operation of plunger (5) also made a circuit which released rotating arm (6) driven by a master clock at the same velocity as the timing disc in the fuze clock, and effected synchronism. Firing relay (7) was mounted on an annular ring and positioned by the existing fire control gear. The method of operation is clearly discernible from the diagram 9A.

(3) Notes.

The Krupp scheme was ready first and was tested in March 1945. While the laboratory tests had turned out well the proving ground tests were unsatisfactory. The fuze was known as "Im Rohr Einstellbare Zunder Zt. Z S/30 M2". The Junghans scheme was not tested.

This method is obviously an improvement over the acoustic system being more widely applicable. The particular embodiment as shown would slow up the firing somewhat and just like the Midgely fuze the error is of the same order as the one they were trying to correct. Because the timing disc makes one-third as many revolutions per second as that of the Midgely fuze the error is about 12° or one second plus. The Germans checked the time lapse between contact and set back on their guns and found that it varied from .05 to .15 seconds depending mainly on the temperature of the powder. From this consideration it no doubt became obvious to them that any system with a revolving timing disc to be locked at set back would be subject to a large error or unduly impede the firing.

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4. Mechanical Time Fuze Devices for Eliminating Dead Time  
(cont'd).

(c) Electrically Set Mechanical Time Fuze.

(1) General.

The development of an electrical system for setting the mechanical time fuze while the round was in the gun barrel was started in 1941 in the Jungheims Research Laboratory at Freiburg. It was originally intended that the system would be used for 88 mm flak but it turned out to require a wire through the round and the breechblock which was objectionable. In 1943 the development was resumed for use with anti-aircraft rocket R 42. The unit to be described is a further simplification over the fuzes actually tested and was made possible by the construction of a high speed mechanical counter.

(2) Description of the proposed Rocket Fuze.

Reference is made to Figure 10 in which a fuze clock is shown as (1) having a cupped timing disc which is adapted to be rotated at 1 RPS by a spring motor. Disc (2) which serves as governor is rotated at 100 RPS by the spring motor. The toothed wheel (3) and the cam (4) are mounted on the same shaft as the disc (2) and therefore also rotate with a velocity of 100 RPS. Thus the cam (4) makes and breaks contacts (5) 100 times per second, shorting out and unshorting resistance R which is placed electrically across the contacts (5).

Separately mounted is an electromagnet (6) to the armature (7) of which is attached pin (8). By operating the magnet the pin (8) releases the toothed disc (3) thereby starting the spring motor which rotates the timing disc on the fuze clock. The number of operations of contacts (5) are counted by an external counting relay and at the desired count the magnet is de-energized, the armature drops pin (8) into one of the ten slots of disc (3) stopping the spring motor thereby arresting the timing disc.

Figure 10B shows a diagram of the arrangement. R is the resistance across the contacts (5) in the fuze. (6) is the magnet by means of which the fuze can be set as described above.

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4. (c) Electrically Set Mechanical Time Fuze. (cont'd).

External to the fuze are contacts  $l_1$  and  $l_2$ , which are made manually as shown,  $l_2$  being the holding contact for the relay L. Depressing switch M starts the operation of setting the fuze. A plus potential through resistor D and point X actuates magnet (6) to start the spring drive and thereby the timing disc. Contacts (5) in the fuze operate and unshort the resistance R in the fuze thereby raising the potential at X, i.e., the alternate high and low potential at X, 100 times per second, caused by the opening and closing of contacts (5) may now be used to set the fuze for the proper "time to burst" while it is in the gun barrel. The counting circuit consists of a five element tube (T) the plates of which are connected to the coils a and b on the counting relay that operates the rotating arm (9). The predictor sets contact (N) to the desired position and when the rotating arm (9) makes contact with N the firing circuit is made.

In this particular circuit the constants are chosen so that when the potential at X is low, making Y negative, the flow of current through plate A and coil a stops. At this moment the potential on A rises and grid Z becomes positive. The tube current now flows through plate B and coil b counting another .005 second step. At each step the rotating arm advances and when it reaches N, as mentioned above, the firing circuit is made. The counting relay is said to be capable of operating on pulses of .004 seconds duration.

It was pointed out above that the fuze was produced in 1945 for the R 42 rocket. When the rocket spin reaches 2000 RPM (some .2 to .3 seconds after firing) the timing disc is clamped to the gear train of the fuze clock by the centrifugally operated clutch shoes (10) figure 8F. At 5000 RPM (.6 to .7 seconds) the coupling pins (11), which have kept the timing disc connected to the spring motor and therefore stationary up to this point, release the timing disc which can now be rotated by the clock. At 8000 RPM (.9 to 1 second) the fuze clock is started by the operation of a centrifugally operated release for the escapement lever (not shown).

(3) Notes.

Because the timing disc rotates at 1 RPS and can be

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4. (c) Electrically Set Mechanical Time Fuze (cont'd).

stopped within 1 millisecond the inaccuracy due to the setting mechanism is exceedingly small dependent only on how closely firing contact N can be set. The spring drive has been worked out so that the gear train between the toothed disc and the timing disc has not lost motion and therefore no error other than that in the fuze clock itself is evident.

The fuzes were tested and pronounced satisfactory for the purpose for which they were intended. In October 1944 Junghans started to produce 7500 units and the first 500 were sent by truck to the loading plant. The truck was destroyed by a bomb, the Germans destroyed all parts in the plant so that no sample is available.

Owing to the limited experience the cost was not known but it was said that the spring motor was much cheaper than the set clock in the 2 clock system previously described.

The fuze was known as "Zt Z. S/30 Fg' mit elektrischen einstellwerk fur R 42 (21.4 cm)" and was procured by O.K.L.

THE MIDGEY TIME FUZE  
UNARMED

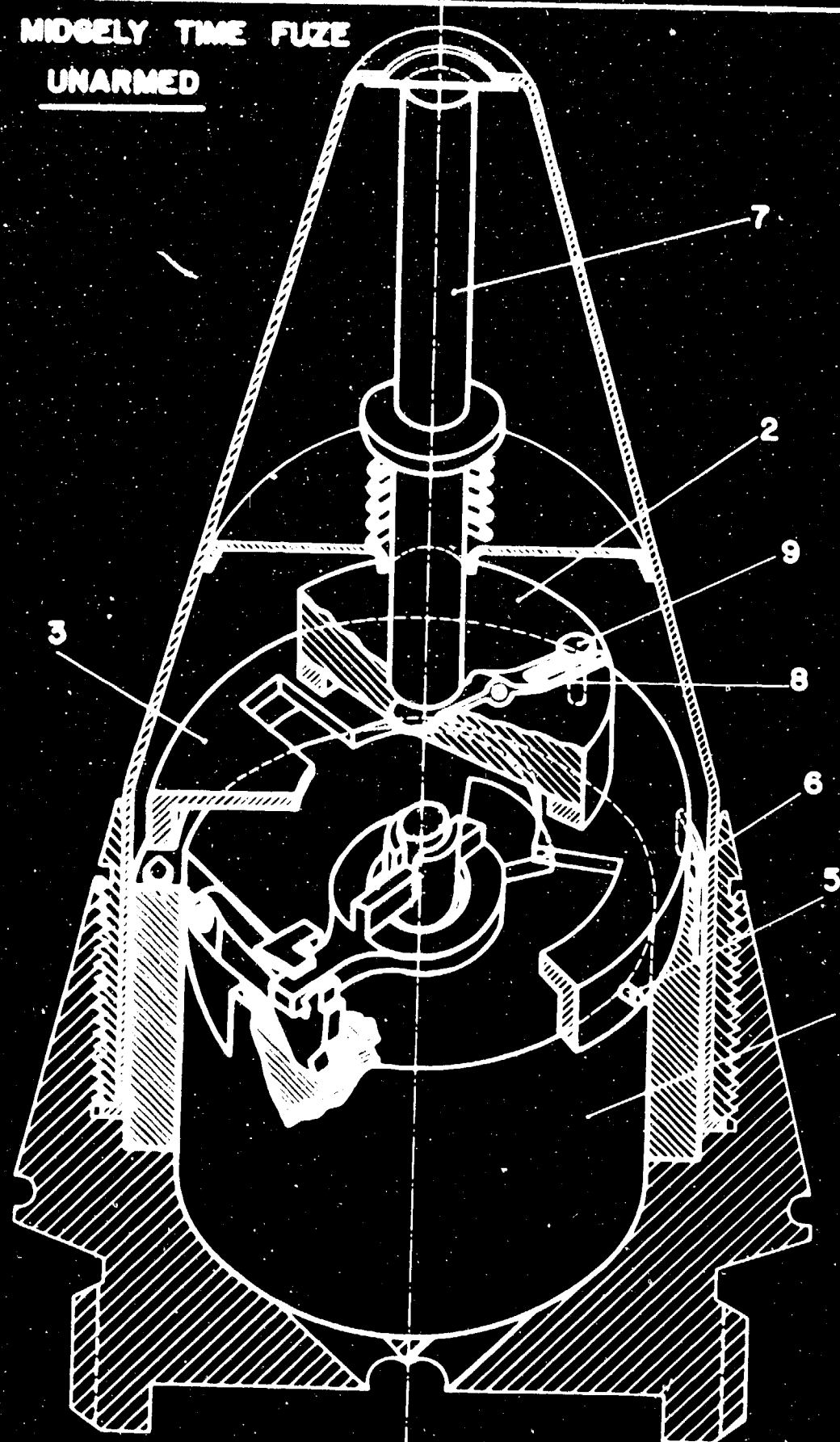
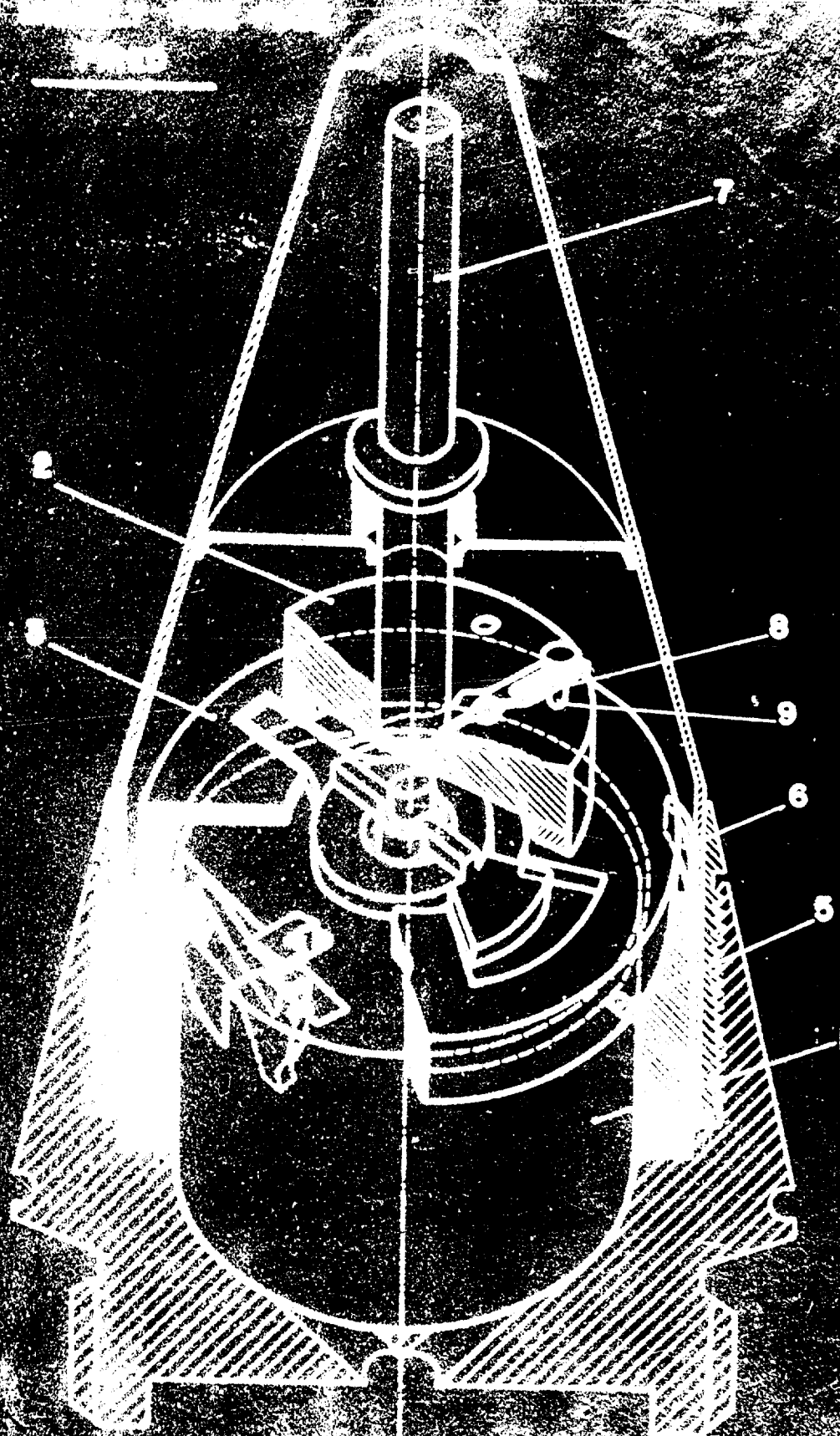


FIG. 8 CONFIDENTIAL



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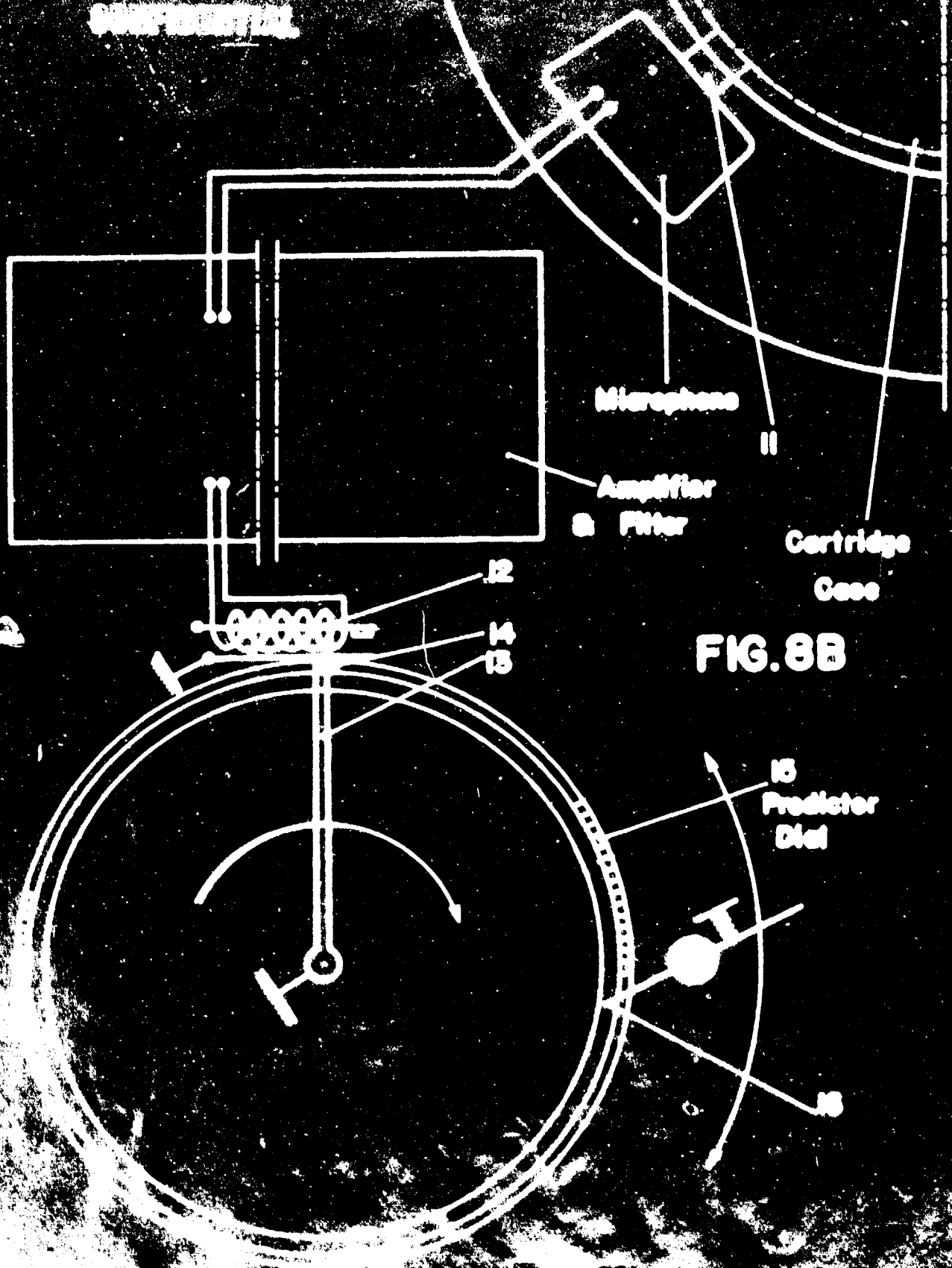


FIG. 8B

THE GERMAN MECHANICAL 2-CLOCK FUZE

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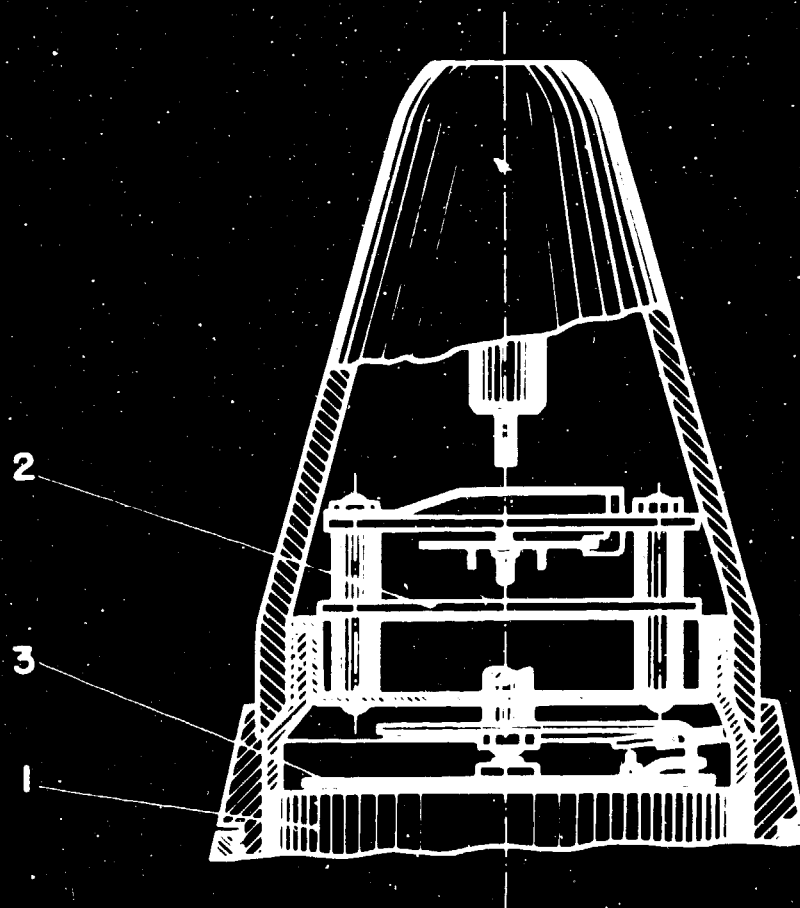
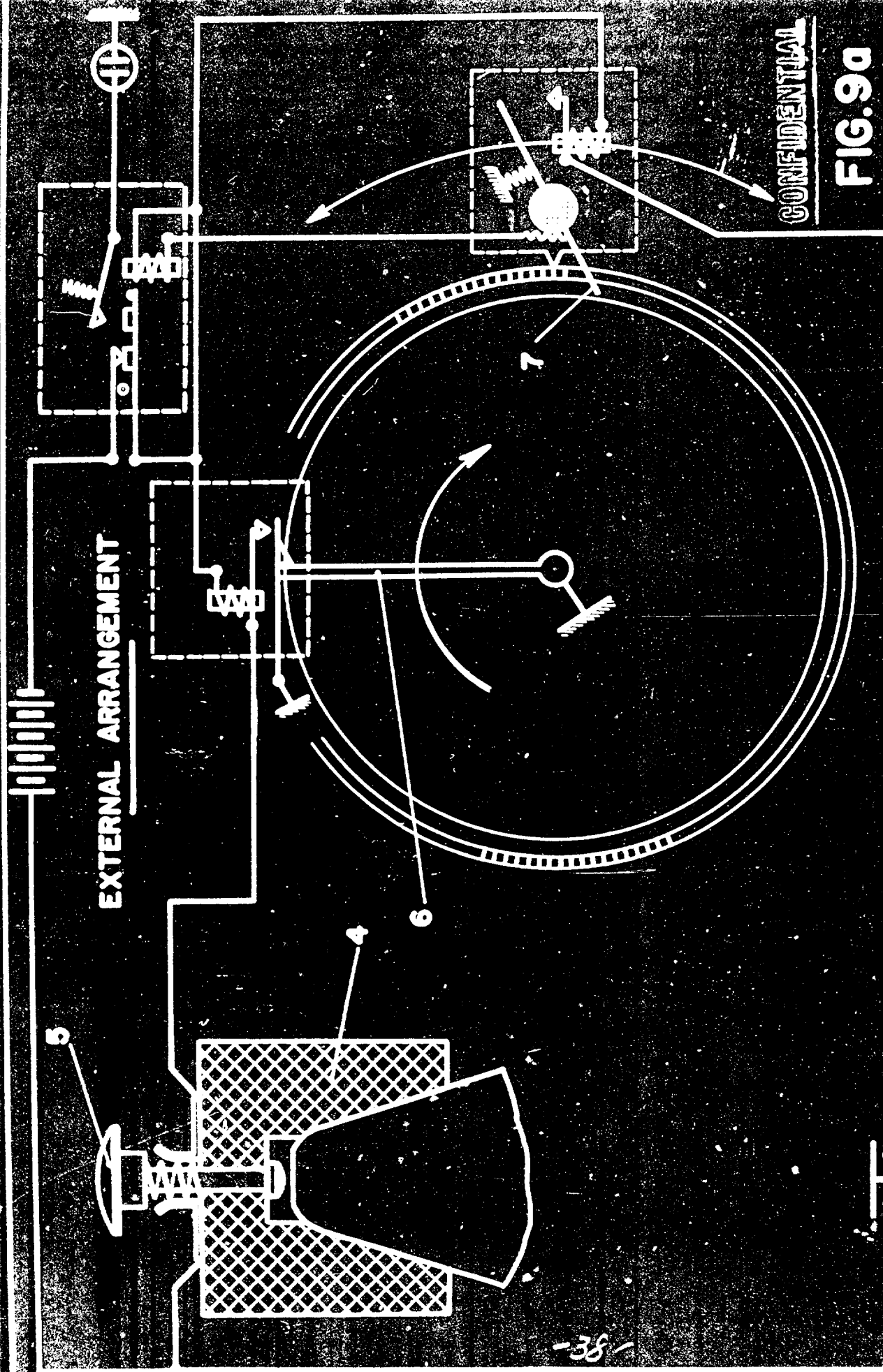


FIG.9



THE GERMAN ELECTRICALLY SET MECHANICAL  
TIME FUSE

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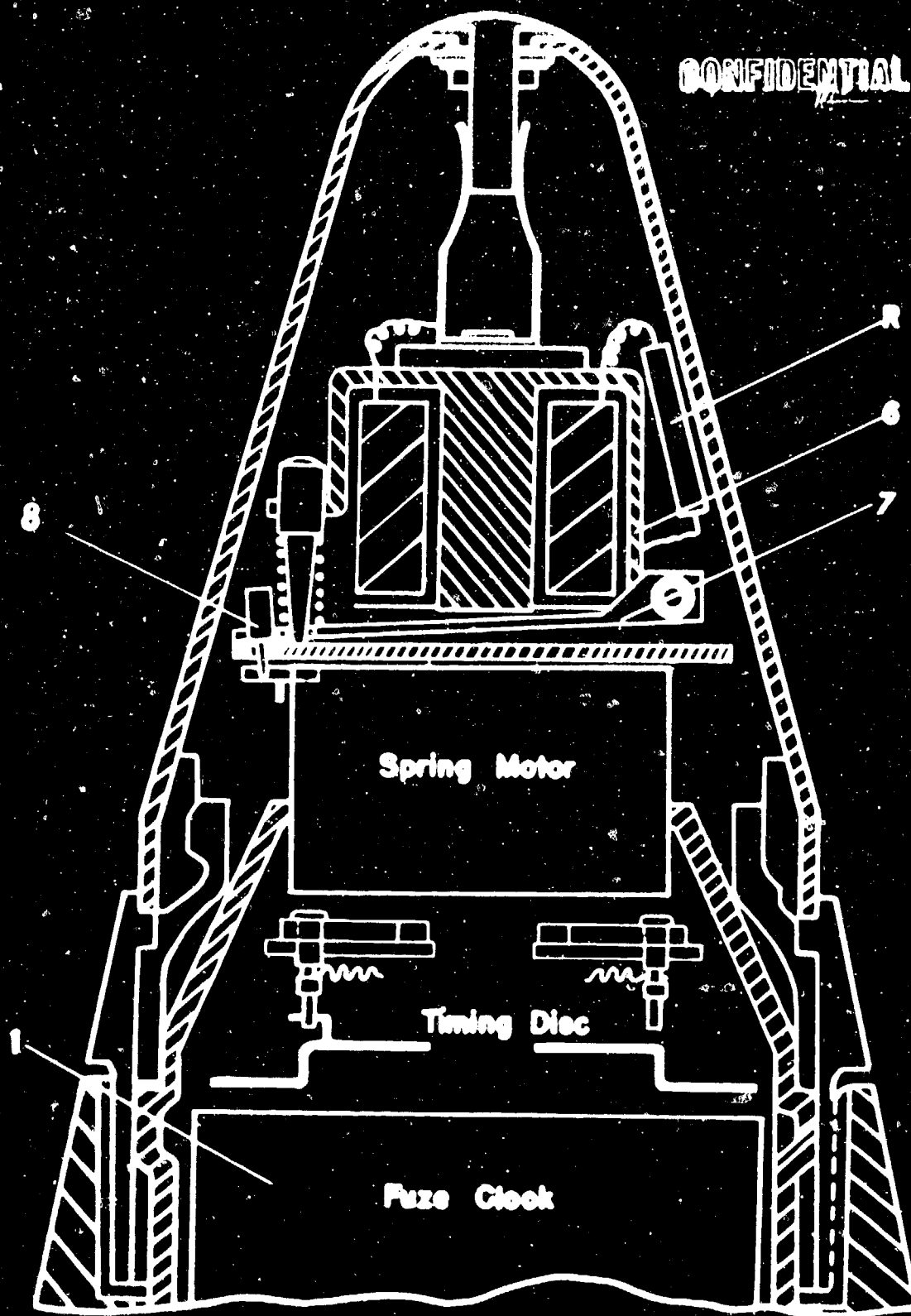


FIG. 10

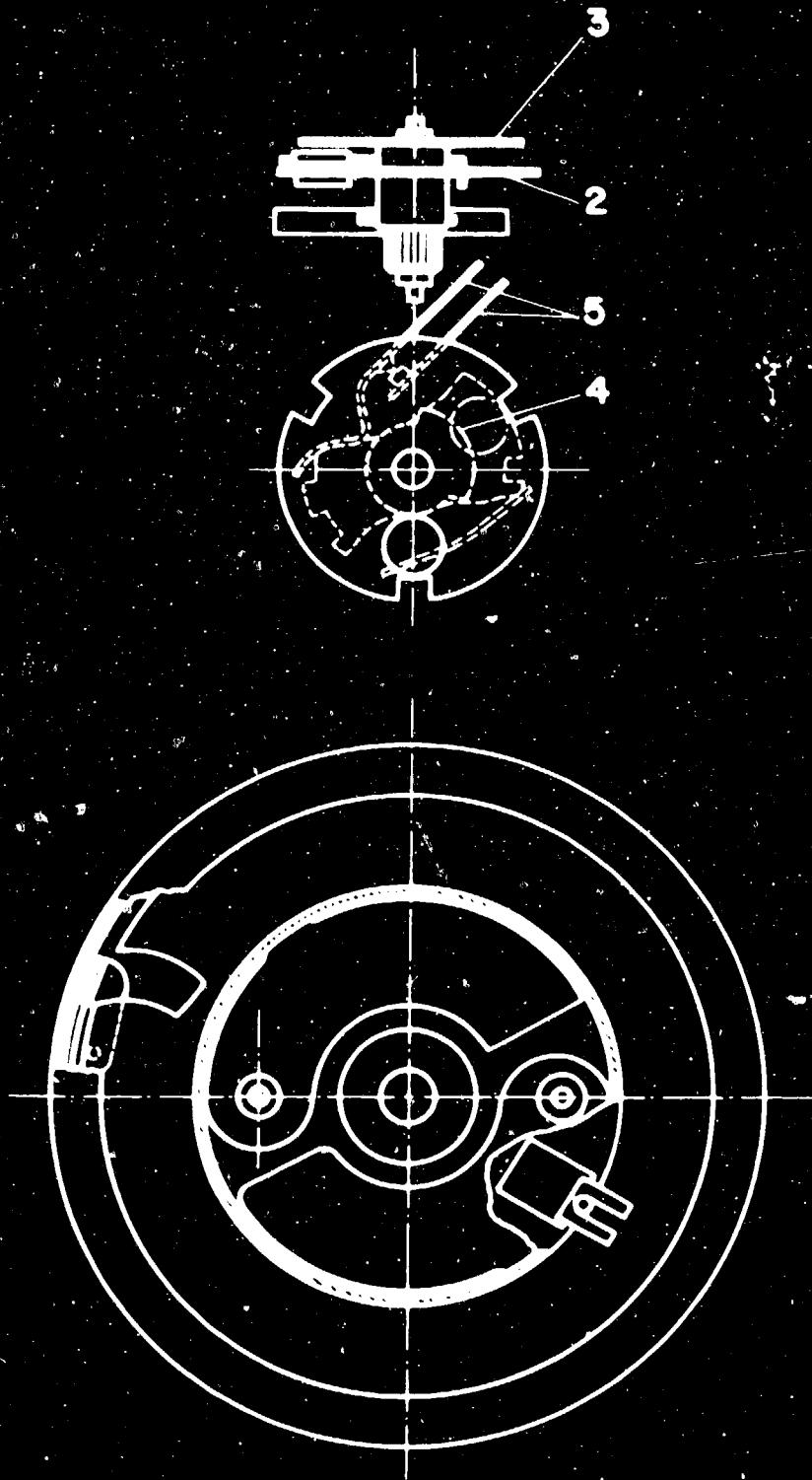


FIG. 10A CONFIDENTIAL

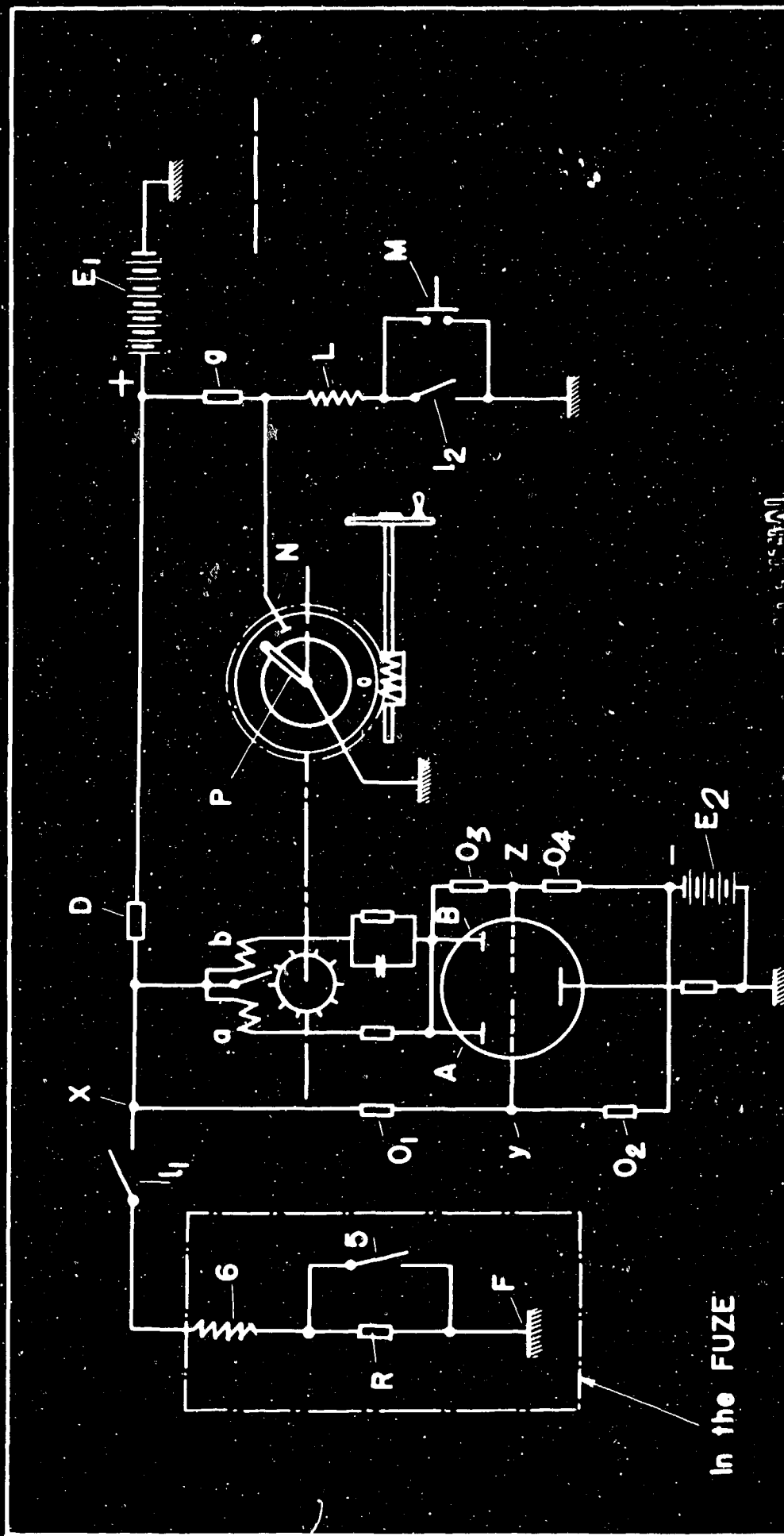


FIG. 10B

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## 5. Miscellany

### (a) Junghans Universal Mechanical Time Fuze.

After some years of experience with centrifugally operated time fuzes Gebruder Junghans decided that a much more useful fuze could be produced by using a spring drive. They avoided the use of a clock mainspring in the light of their own and Krupp's experience with breakage of the conventional mainsprings. They believed that the fuze should have an impact element to make it more useful and that the clock should be small to fit into squeeze bore projectiles.

The development of this fuze, known as "Vereinfachter Zeit Zunder, Kleinwerk, mit Zugband Antrieb" was started in 1944 and a few hundred samples were made. Twenty units were tested and found to be satisfactory, however, the O.K.L. wanted the clock made still smaller but the war was over before the redesign could be started. The clock, as made, was 32 mm in diameter (standard 38) and was driven by two helical springs operating normal to axis of the clock, rotating the central pinion by means of a steelband. A complete set of working drawings has been forwarded to CNO (Op-16-PT).

### (b) Mechanic 1 Time Fuze for Spin Stabilized Rockets.

The "Junafrau" design previously described was revised by substituting centrifugally operated elements for those that were operated by setback. About 25,000 units were made for 21 cm diameter rockets and larger. The ogive of the rocket was extended to completely house the fuze and an additional external hammer was made to project in front of this windshield to actuate the point detonating element of the time fuze. This fuze was known as R. Dopp Z S/60.

### (c) Self Destruction Fuze (Rotating).

During January 1945 a simplified self destruction element was developed for the 37 mm fuze. Figure 11 shows the working principle of the unit. In the figure (3) is an arm secured as shown but free to move outward when the bullet spins. Spring (5) is loaded by the motion of the arm. After the spin has diminished to the desired extent the loaded spring overcomes the centrifugal force

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5. (c) Self Destruction Fuze (Rotating) (cont'd).

on the arm allowing it to move inward. The closer it approaches the center the more rapid is this motion and finally it fires primer (4). The gas pressure acting on the enlarged portion of the firing pin (2) causes the firing pin to fire the main primer thereby destroying the bullet.

60 units were made by hand were found to be satisfactory. The design was sent to the O.K.L. for approval just about the end of the war. It should be noted that the aluminum spiral as divided makes an excellent and inexpensive detent. Tests show that at 30,000 RPM the bullet is safe (Maskensicherheit) 45 feet beyond the muzzle in the 3.7 mm design. At 50,000 RPM the bullet is safe 24 feet beyond the muzzle in the 20 mm design.

The described unit was intended to provide a less expensive fuze than used previously and was called "Verinfachter 3.7 cm Zerleger". It was adjusted in the factory by bending the tail end of the spring.

The fuze it was to replace cost 1.88 marks and the smaller fuze cost .61 marks. The aluminum spirals were made on special machines at the rate of about 100 per minute.

(d) Self Destruction Fuze (Non-rotating).

The fuze shown in Figure 12 was never designed but the prospective designer thought it could be made somewhat as indicated. The block (1) provided with the slotted plate (1a) is resting on the plate secured by spring (3) and encompasses the firing pin (2). By setback (about 40 g) the block moves downward and rotates the firing pin. This rotation winds the spring (4) by moving sector (8). After the bullet is in flight, spring (4) operates sector (8) which is slowed down by the ratchet (12) through wheels (9, 10 and 11). The self destruction firing arm (5) previously cocked on the halfshaft (8a) is released when the shaft (8a) has moved sufficiently and strikes the primer (7) whereupon the gas pressure operates firing pin (2) and the bullet is destroyed.

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5. Miscellany (cont'd).

(e) Electric Fuze for Hollow Charge (100 mm projectile).

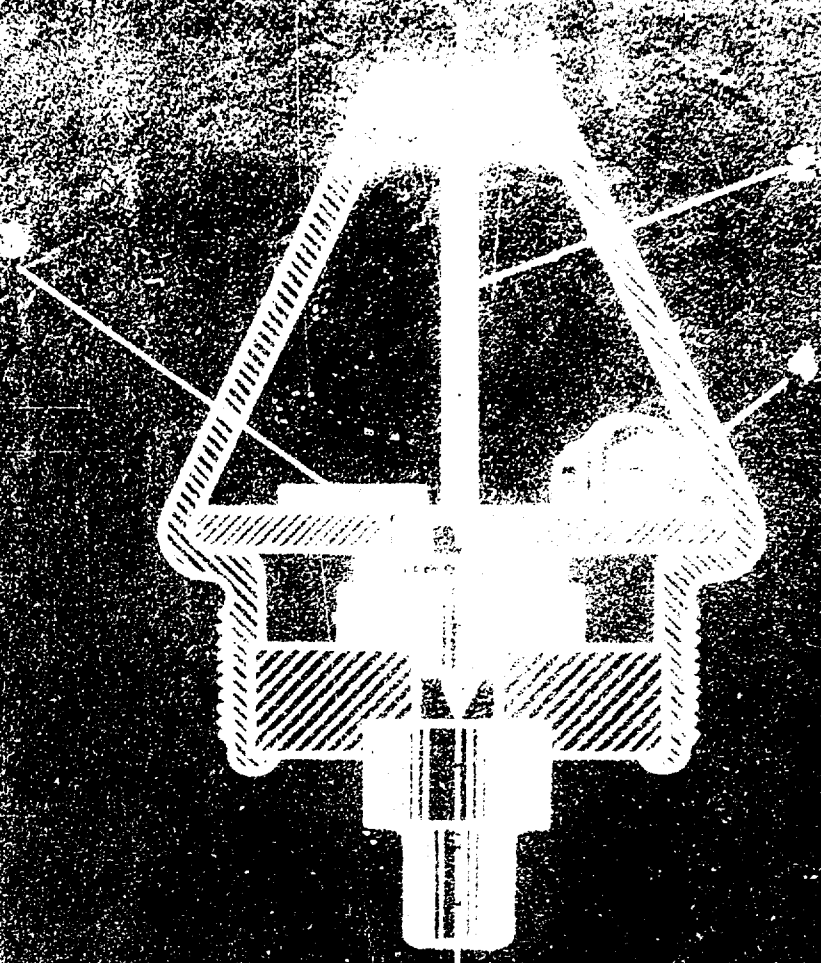
To secure the fast fuze response required for a hollow charge the Germans developed an electrical impact fuze which generated its own current. Within a cylindrical enclosure 22 mm in diameter and 37 mm long was spring mounted a permanent magnet cup and soft iron core containing a winding which terminated in two plugs. Exterior to cup was placed .1 MF condenser. The cup was shorted at its open end by an iron keeper secured to the external structure. At the moment of impact the magnet assembly moved away from the keeper the resulting voltage (180-200 V) charged the condenser and fired a sensitive electric squib. The unit seemed to be in the development stage and no samples are available.

(f) Tachograph for Recording Spin.

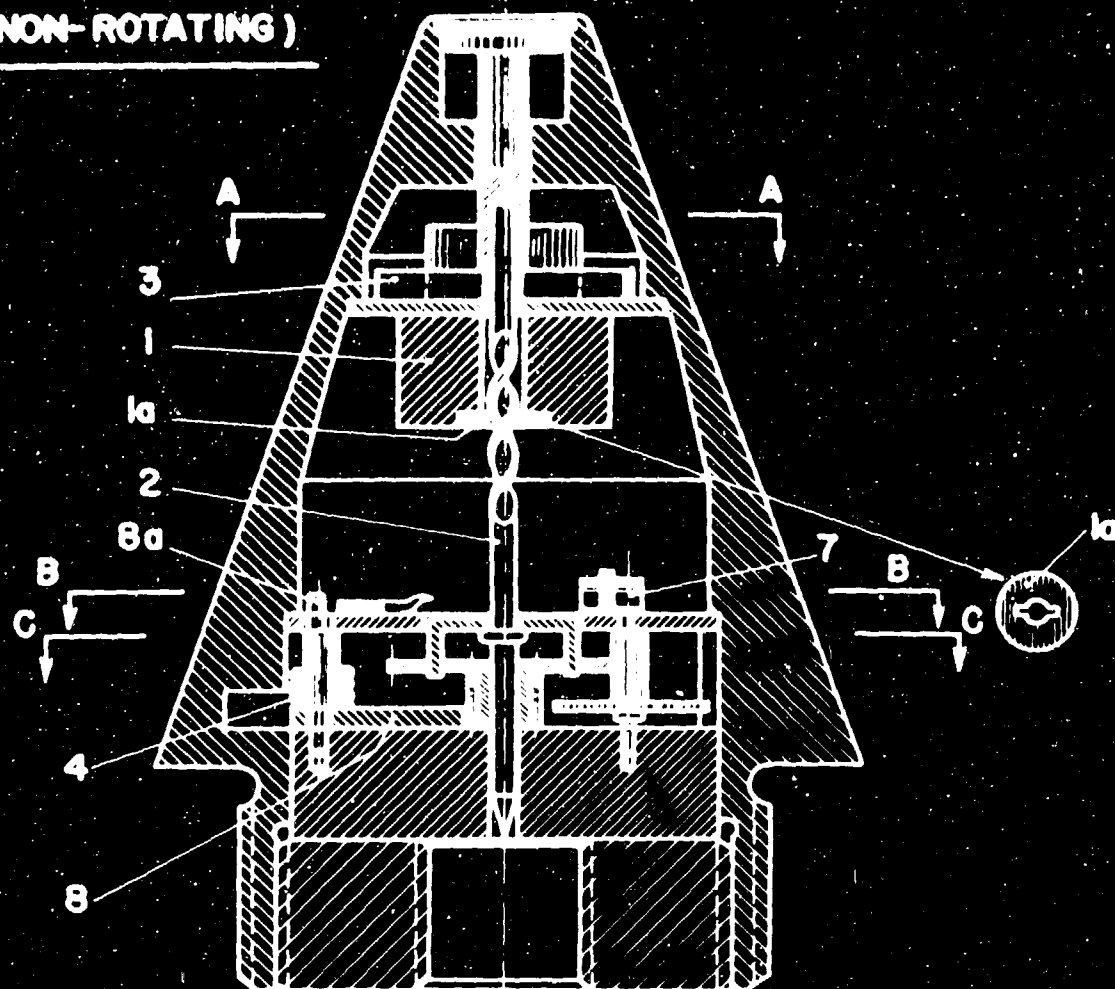
Utilizing a mechanical time fuze clock with suitable recording point and disc enabled the Germans to find the spin of projectiles and rockets in a simple yet seemingly sufficiently accurate way. Working drawings together with curves plotted in a few tests have been forwarded to CNO (Op-16-IT).

Prepared by:

K. G. BERGGREN,  
Technician.

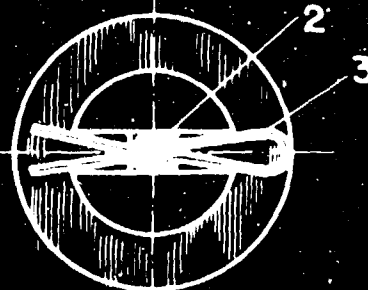
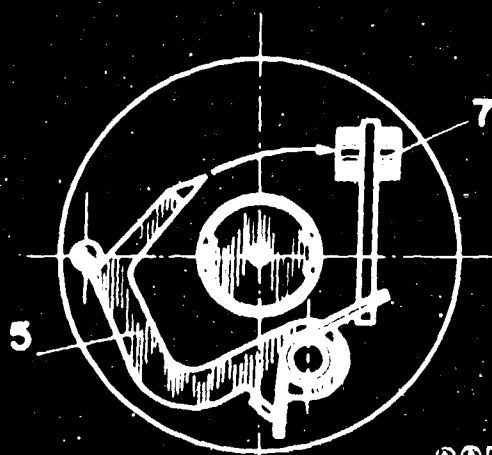


**37 MM FUZE WITH SELF DESTRUCTION ELEMENT  
(NON-ROTATING)**

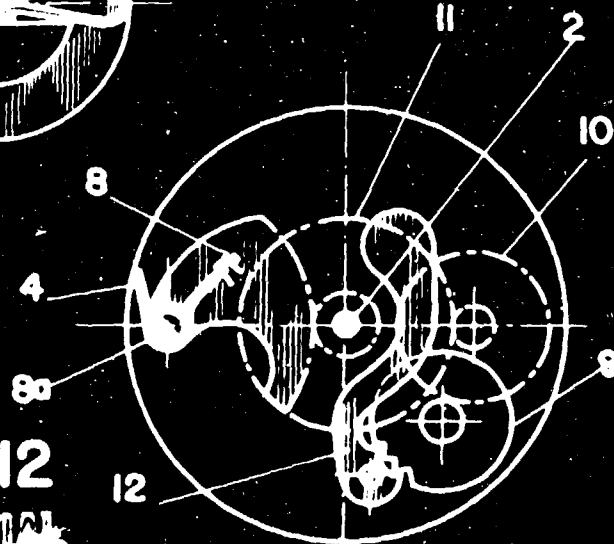


**- Section AA -**

**- Section BB -**



**- Section CC -**



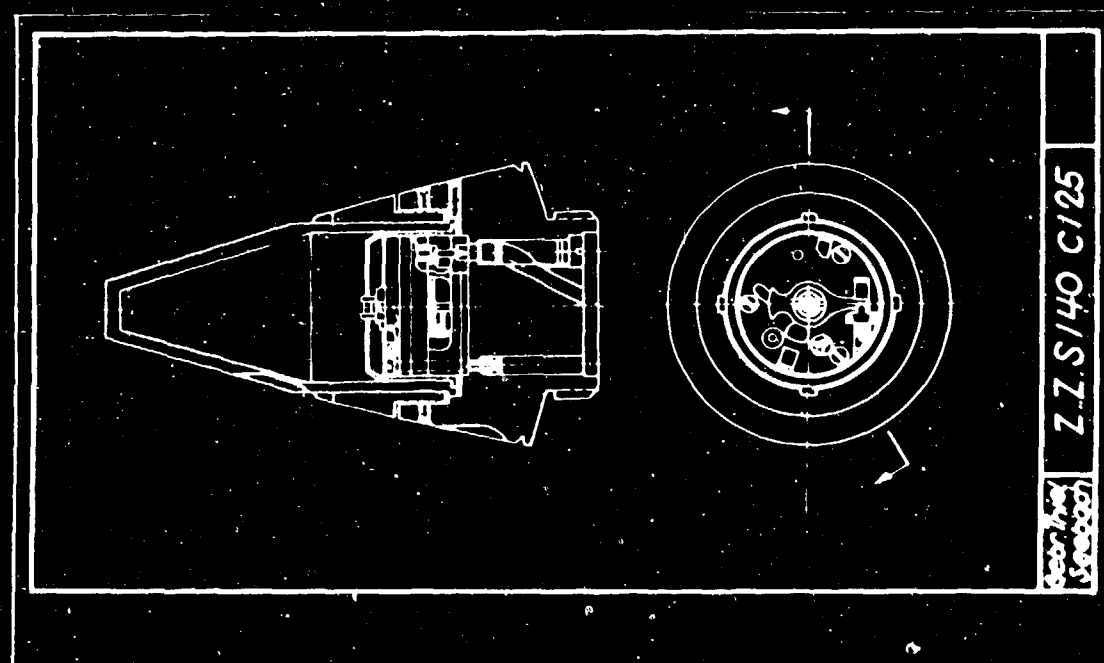
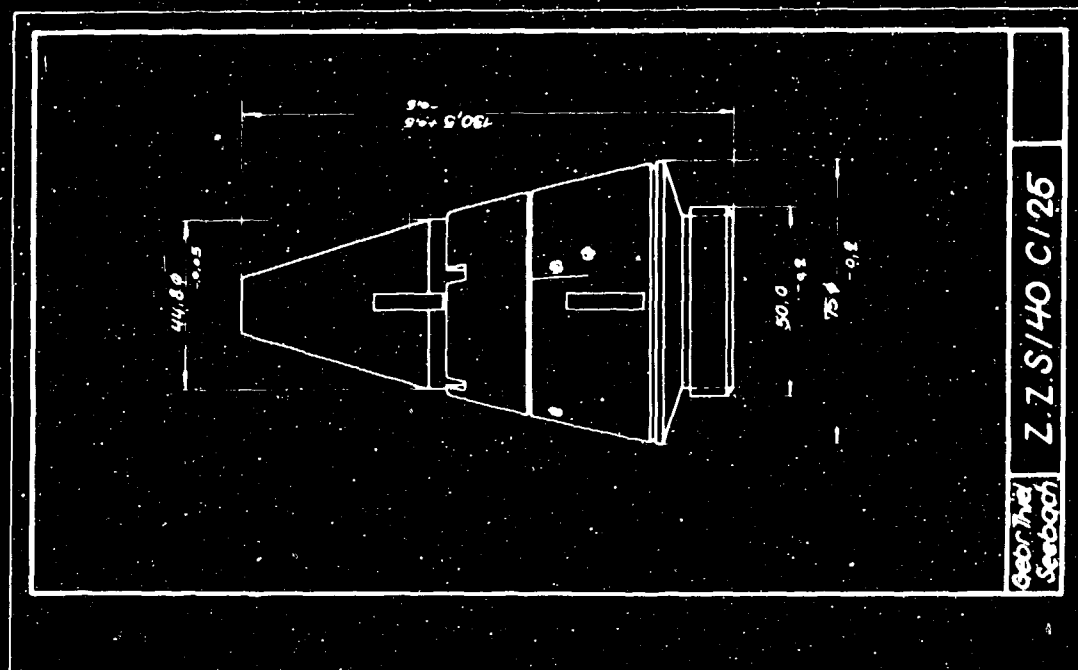
**FIG. 12**

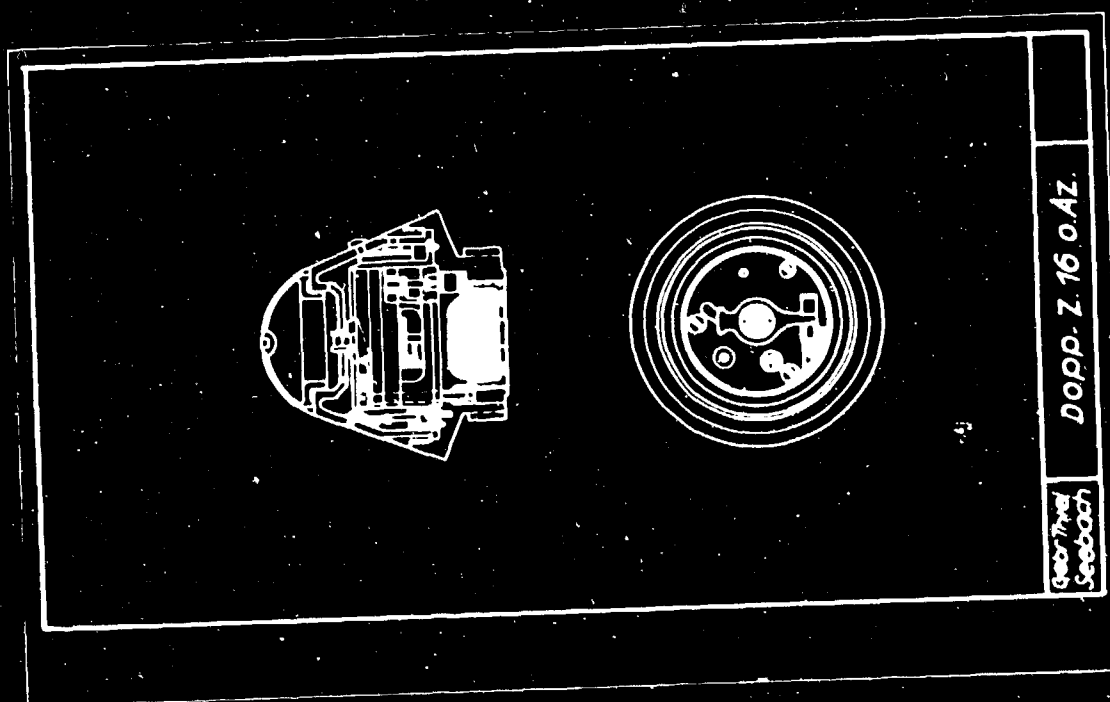
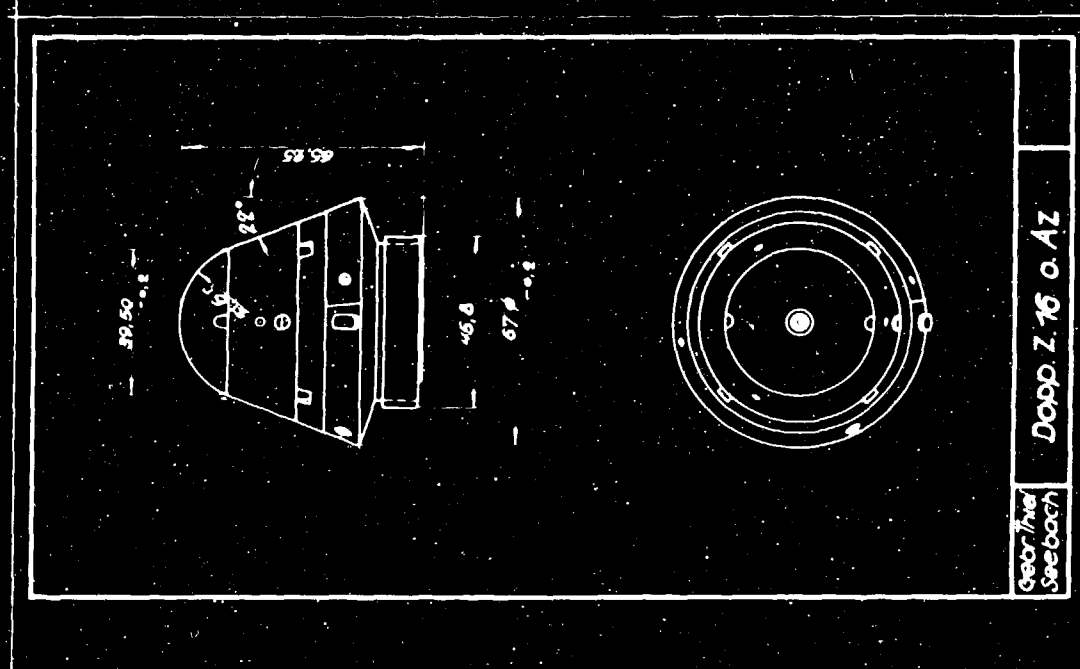
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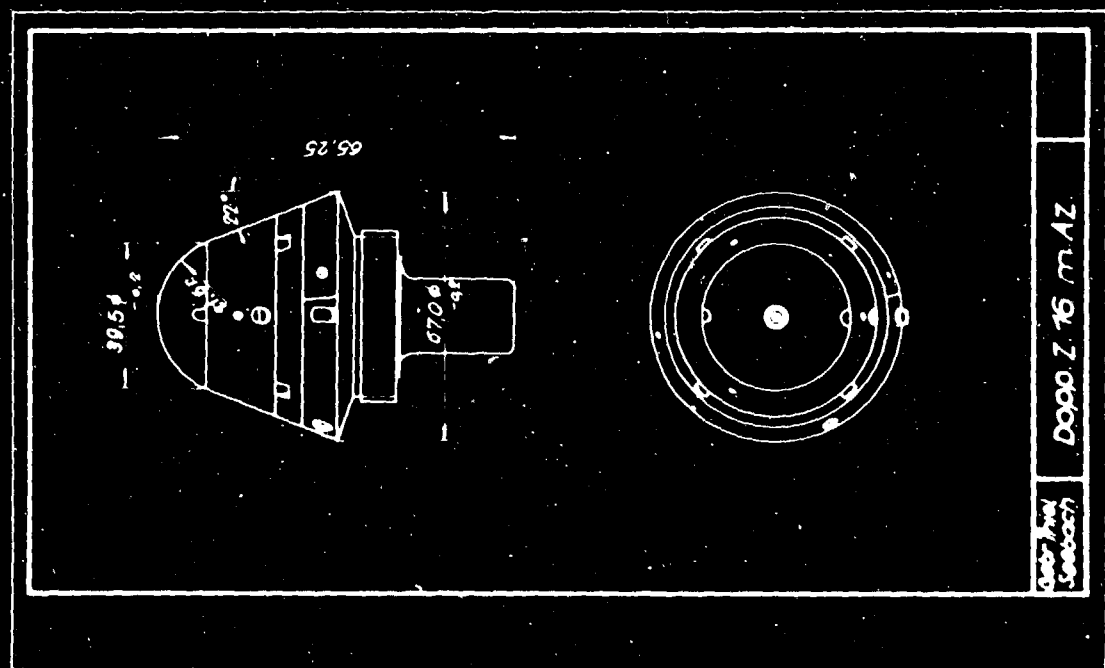
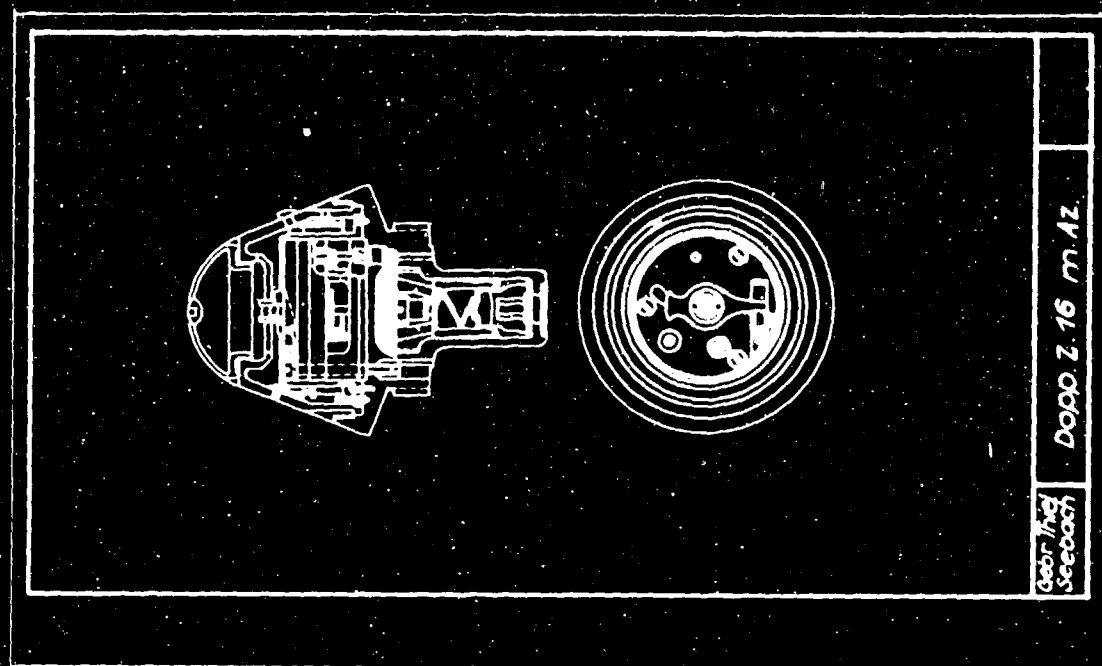
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APPENDIX I

FORMS OF GERMAN TIME FUZES.

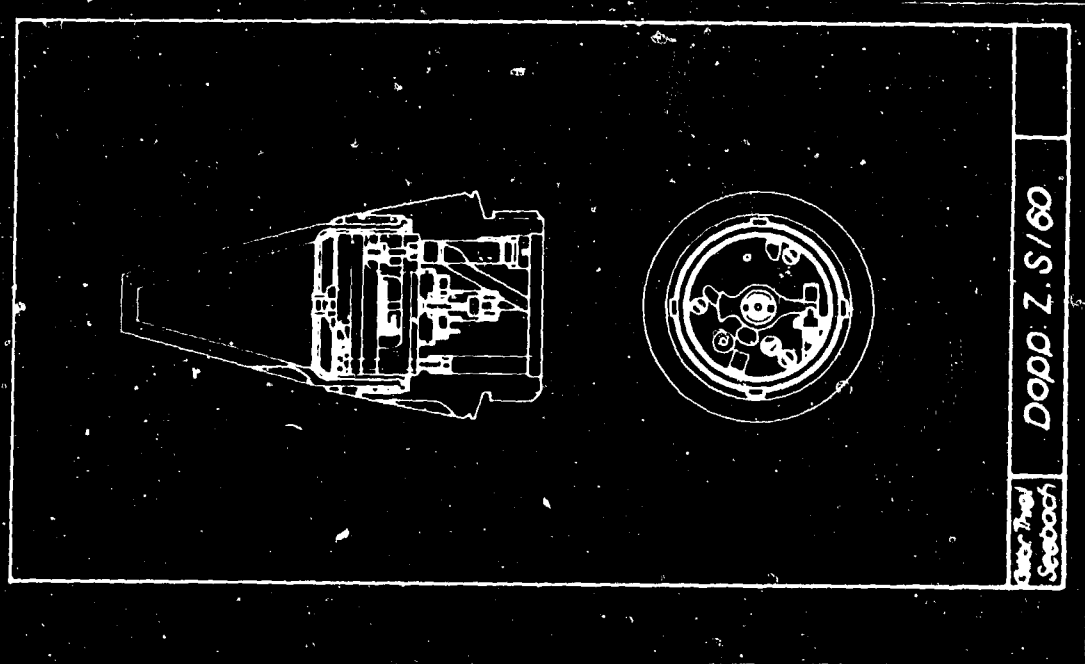
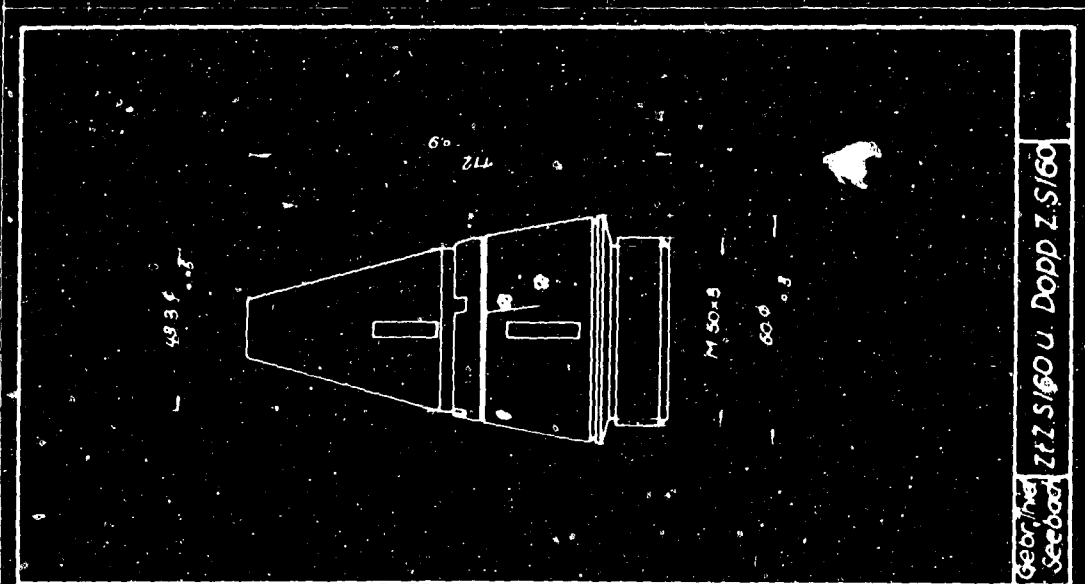












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APPENDIX II

For a comprehensive survey of German Fuzes reference is made to U. S. Naval Technical Mission in Europe Technical Report No. 191-45, prepared by Lt.(jg) R. L. Gellein, USNR.

The Fuze designs dealt with in this report were screened out from a large amount of material and were, in the main, proposed too late to be used in actual warfare.

The material reported on here was collected, screened and evaluated by:

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Lieut. R. E. WATSON,  
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